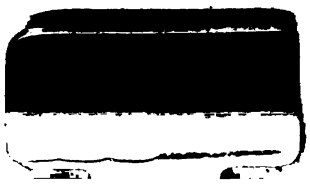
KEYSTONE INSTRUMENTS

I·T·E

SWITCHBOARD PRACTICE

THE PRINCIPLE THAT MAKES CIRCUIT BREAKERS PRACTICAL



I-T-E
SWITCHBOARD
PRACTICE

A SUPPLEMENT TO "MODERN SWITCHBOARDS," PUBLISHED BY US IN 1898, AND FOR SOME TIME OUT OF PRINT

THE CUTTER
ELECTRICAL AND MANUFACTURING CO.
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TABLE OF CONTENTS

TABLE OF CONTENTS—CONTINUED

ILLUSTRATIONS

ILLUSTRATIONS—CONTINUED

FOR SMALL FEEDER OR MOTOR PROTECTION:

FOR GENERATORS OR FEEDERS AND LARGE MOTOR PROTECTION:

DIMENSIONAL DIAGRAMS OF KEYSTONE MEASURING INSTRUMENTS:

FOR DIRECT CURRENT ONLY.

FOR DIRECT OR ALTERNATING CURRENT.

SPACING.

INTRODUCTION.

One reason why the American manufacturer is making such rapid strides in the markets of the world is his employment of ELECTRICITY. By its use he turns NIGHT into DAY, and gets greater speed and efficiency from his machinery. Replacing slow and ineffective hand labor by high-power, electrically-operated machines and automatic devices, he not only vastly increases the output of his establishment, but at the same time improves the quality of the product and insures its uniformity.

To-day hardly an industrial plant is without its electrical equipment, be it an immense isolated plant or a few motors. In any case, the user of electricity cannot fail to be keenly interested in the subject of AUTOMATIC CIRCUIT BREAKERS. It may no longer be necessary to tell what a Circuit Breaker is, but we may be allowed to call attention to the scope of our work in this field, pointing out the value of I-T-E CIRCUIT BREAKERS as a means of automatically opening any electrical circuit. There are, perhaps, few engineers who fully realize the almost unlimited usefulness of this device.

Primarily, the Automatic Circuit Breaker is a Safety Device. Some have called it a "Limit Switch," while others have named it an "Electric Safety Valve," or "Cut-out;" it has, in fact, the features indicated by all these names.

The field of Automatic Circuit-Breaking was, in its earlier days, limited to protecting circuits and apparatus from overloads; to-day, however, Automatic Circuit Breakers are made to meet, either separately or in combination, a wide variety of other conditions equally important.

It would be impracticable to cover all the possibilities of Automatic Circuit-Breaking within the limits of this publication, but the

following may suggest some of the more usual conditions with which the various types of Automatic Circuit Breakers are designed to deal:

Overloads or Excessive Currents.
Cessation of Line Pressure or Voltage.
Diminution or Cessation of Current.
Reversal in the Direction of Flow of Current.
The Occurrence of Predetermined Mechanical Conditions.

I-T-E AUTOMATIC CIRCUIT BREAKERS, as made by the Cutter Company, of Philadelphia, have been specially designed to meet all of these conditions, either separately or in combination, as required. It is the immense scope of our work in the Circuit Breaker field which has made the I-T-E Automatic Circuit Breaker known all over the world.

WM. M. SCOTT, Engineer

THE PRINCIPLE OF AUTOMATIC CIRCUIT BREAKERS

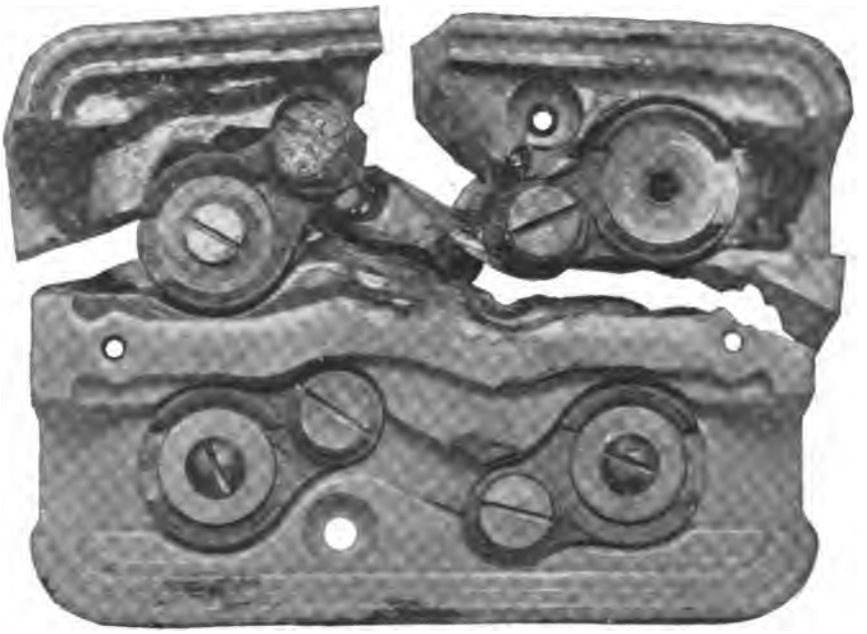
The I-T-E Automatic Circuit Breaker consists primarily of a switch for opening and closing the circuit; a spring to open the switch; a latch to restrain the switch against the action of the spring; and a coil or coils, with suitable mechanism controlled thereby, for disengaging the latch upon the occurrence of the condition to which the Circuit Breaker is designed to respond.

The point at which the Circuit Breaker will operate is determined by the relation of a given weight to the magnetic field resulting from the operating current. The action of the instrument, therefore, at any given adjustment is as constant as gravitation can make it. When it is set to operate at a particular current, it opens immediately the current reaches that value. A single instrument may be adjusted to respond to any particular current within a wide range. Its operation is positive and the arc is always instantly broken.

CIRCUIT BREAKERS CONTRASTED WITH FUSES.

In the early days of electricity, when the questions of efficiency and economy were not given the attention that they receive to-day, **overload** protection was supposed to be provided for by the use of fuses; but many of the classes of work to which the Automatic Circuit Breaker is **now** adapted do not come within the scope of fuses at all. It is, in fact, only where overload protection is concerned, and that for small currents, that the fuse can be considered.

The fuse at best is uncertain. At times, owing to mechanical defects, it blows prematurely; more often, however, it will carry continuously a current much in excess of its rated capacity. Aside from this uncertainty of action, the blowing of the fuse is likely to be destructive to the tablet upon which it is mounted, and involves in many cases a serious fire risk. The fuse cannot be instantly replaced; in fact, its sole recommendation is its low first cost.



A fuse block which has seen service.

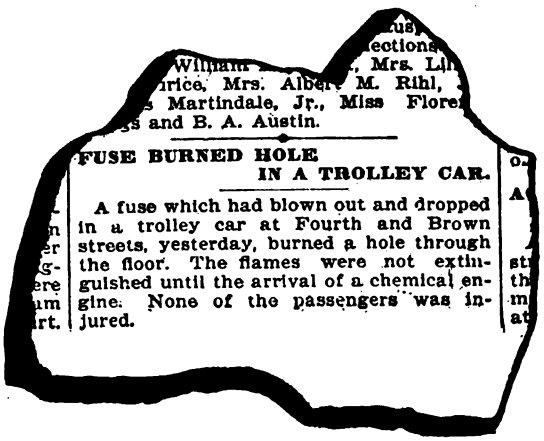
While as compared with the fuse its initial cost may seem high, the I-T-E AUTOMATIC CIRCUIT BREAKER in use soon demonstrates

its value as a money-saver. It is on this account that users of electricity everywhere are discarding fuses in favor of Circuit Breakers. Compare the resetting of a Circuit Breaker with the replacing of a spent fuse, and one of its many economies will at once be obvious. It saves time, and certainly in the commercial world "time is money."

Again, Circuit Breakers never fail to protect the apparatus. That is another reason why they save money. But what has been fully proved by practice needs no further argument. The thousands of instruments now in service on light, heat and power circuits speak for themselves.

Another reason why the use of Automatic Circuit Breakers has become so general is because their employment materially lessens the labor of operating an electric light or power plant, often rendering it possible for one man to assume entire management of an installation, when but for the use of the Automatic Circuit Breaker he would require assistants.

In many localities it is frequently impossible to secure men of sufficient technical knowledge to properly handle the electrical apparatus without the use of Automatic Circuit Breakers. The men available may be entirely ignorant of electricity, or may have grown up in its use without a full knowledge of its possibilities. In such cases I-T-E AUTOMATIC CIRCUIT BREAKERS prove of great assistance to the engineer, acting as they do as tell-tales for the entire equipment, reducing the cost of maintenance, as well as rendering available the full capacity of the plant.



THE CIRCUIT BREAKER AN INDICATOR.

The I-T-E AUTOMATIC CIRCUIT BREAKER is an indicator. It tells, as nothing else can, what is going on in your circuit. Are your motors being started carelessly? The I-T-E Automatic Circuit Breaker will tell you. Is there undue friction in your motor-driven machinery? The I-T-E Automatic Circuit Breaker will discover it. Are your generators or motors being overloaded? Protect them with I-T-E Automatic Circuit Breakers and you will soon know where the trouble lies. Are your motor armatures burning out? I-T-E Automatic Circuit Breakers will tell you why and will remedy the difficulty. Is your storage battery **discharging** into your mains, when it should be **charging** from them? The I-T-E Automatic Underload Circuit Breaker will indicate the trouble and prevent damage from it. These and many other abnormal conditions to which electrical apparatus is liable will be promptly detected by the I-T-E Automatic Circuit Breaker, and in most cases the instrument not only discovers the difficulty, but provides the remedy as well.

One extensive user of I-T-E Circuit Breakers says of them:

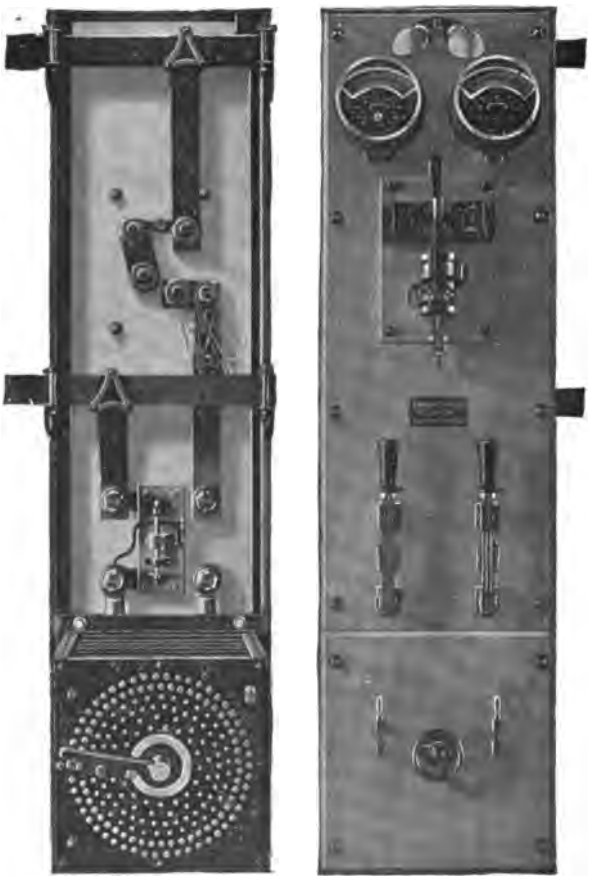
"They are giving us very good satisfaction, especially in the lines of finding out defects in our apparatus, as well as defects in the handling. By closely watching the Circuit Breakers going off and investigating the cause we are enabled to trace the cause in many instances to slight defects in the machinery, either in the electrical connection or some of the working parts."

When you have decided that you want the protection afforded by an Automatic Circuit Breaker, be sure that you get the best. Under **normal** conditions no Circuit Breaker is required, but **abnormal** or unusual conditions are of frequent, if not of daily or hourly occurrence in any electric plant. The Circuit Breaker

should be built to withstand severe use. The I-T-E Automatic Circuit Breaker is simple and strong in construction, is made with interchangeable parts, with all the circuit-breaking parts exposed to plain view. It is easily adjusted, is accurate and constant. All of these points and many more make it **especially** able to withstand the severest use, and render the I-T-E Automatic Circuit Breaker the most perfect automatic safety device, both theoretically and practically, for electric circuits on the market to-day. The **"I-T-E"** embodies **the principles that make Circuit Breakers practical.**

CIRCUIT BREAKERS FOR THE PROTECTION OF GENERATORS.

As the most common danger to which generating apparatus is subject is that resulting from overloading, the "Overload" Circuit Breaker finds a wide field in the protection of generators. In many places the single pole "Overload" instrument gives all the protection that is required. Particularly is this the case in plants where but one generating unit is employed, or where a number of machines being operated in parallel, it is not considered essential that the opening of the Circuit Breaker kill the field due to



the series coil of the generator whose circuit has been opened. Where, however, this is required, a **double** pole instrument must be employed. In case the circuit breaker displaces the usual hand-switch, a double pole instrument is, of course, necessary.

While perhaps the commonest cause of overloading of generators is found in excessive demands from the external circuit, there are numerous conditions which may arise inside of the central station, which, if not checked, result in overloads quite as serious as those resulting from external conditions.

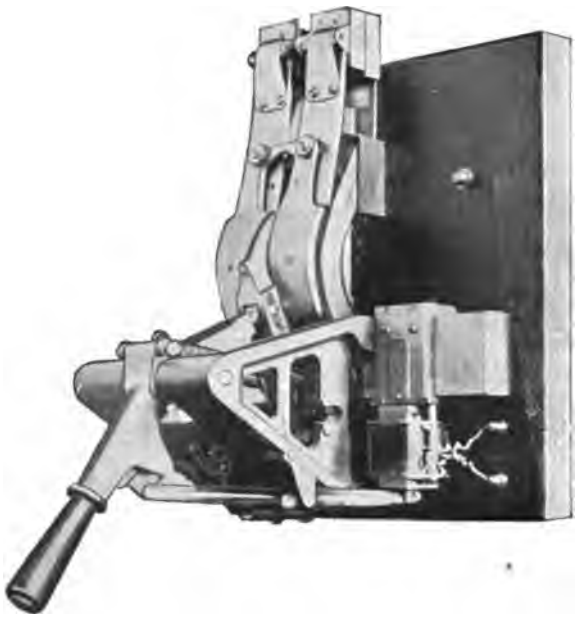
Where generators are operating in parallel, a slowing down of the prime mover of one or more, or an interruption of any one of the field circuits, is likely to cause serious disaster if not suitably guarded against; the tendency of the generator affected being to run as a motor. This is bound to result in its own mechanical injury and the overloading of the other generators; for not only must they now supply to the bus bars the current required by the external circuit, but that demanded by the one-time generator as well. Even so apparently insignificant a matter as the burning out of the field rheostat of a generator running in parallel with others, may in this manner be the cause of serious loss and inconvenience. As an instance of the liability of such reversals, we quote from the letter of an engineer of large experience:

"We had a bad accident at the power-house a few evenings ago—caused by exciter trouble. We had two exciters working in multiple, and at about 10 P.M. the switchboard attendant shut down one of the generators, cutting off the field, which slightly reduced the load on the exciters. For some reason or other one of the exciters dropped its load. We could not learn exactly how this occurred, but believe the water-wheel governor shut down the water-wheel driving the exciter. As the gate of the wheel closed, the exciter dropped its load and then began to take current as a

motor. This overloaded the remaining exciter until the load was so high that the voltage dropped and the fields of the generator weakened enough to drop the total load of the station.

"The trouble would have been avoided had we been equipped with Reverse Current Circuit Breakers."

Engineers on the Continent and in England have more fully appreciated the dangers to which generators running in parallel are subjected on account of such possibilities, and with them it is ordinary practice to protect such apparatus with Circuit Breakers which open the circuit upon **reversal** of the current. It was to meet conditions such as these that the instrument shown in the cut was designed. It has a rated capacity of 3,000 amperes, and while it may be closed or will remain closed on line pressure, even though no current is flowing in the main coil, it opens the circuit immediately upon a reversal of current to the amount of 70 amperes. This instrument forms a part of the installation of the power plant of the Metropolitan Underground Railway System of Paris.



Instruments having this feature are also made with overload operation, thus providing most completely for the protection of the generator.

In the case of ALTERNATING CURRENT GENERATORS operating on single-phase systems, requisite protection from overloads may be secured by the use of single pole Circuit Breakers of the alternating current type.

For two-phase alternating current generators, double pole Circuit Breakers should be used. These instruments, for this class of work, are provided with two operating coils, one to be connected in each phase; thus the opening of the circuit will be insured in event of an overload, whether the system be balanced or not.

Double pole, double coil instruments are also admirably adapted for the protection of three-phase generators.

Double coil **triple pole** Circuit Breakers not only afford perfect protection for three-phase generators, or Edison three-wire systems, but entirely disconnect the apparatus from the circuit in the event of an overload.

Very useful adjuncts for Generator Circuit Breakers are described under the headings, "Auxiliary Coils" and "Insulated Buffers," in succeeding chapters in which the subject of Circuit Breaker Accessories are more fully treated.

SOME SPECIAL TYPES OF I-T-E CIRCUIT BREAKERS AND CIRCUIT BREAKER ACCESSORIES.

In the design and construction of I-T-E Circuit Breakers, among the many important points never lost sight of is that of insuring proper operation of the instrument from any point within its range of adjustment. The restraining latch must secure the switch firmly in position, so that the instrument will open only upon the occurrence of a predetermined current flow, while the solenoid and plunger must develop ample energy to insure its release upon the occurrence of the least current for which the instrument is set. This certainty of action can only be secured by making the lowest limit of the adjustment of the instrument bear a certain relation to the number of turns in the operating coil. For this reason standard types of I-T-E Circuit Breakers are never calibrated to provide for lower adjustment than that corresponding with 25 per cent. below the rated capacity of the instrument. In most instances, the minimum adjustment as thus determined is more than ample, especially when the circuit breaker is used on a power or lighting circuit, where the conditions under which it is operated are comparatively constant.

The maximum limit of adjustment is determined so that the heating, when continuously carrying the corresponding current, will not exceed by more than 65 per cent. that incident upon operation at rated capacity. This point coincides with an adjustment of 50 per cent. in advance of the rated capacity of the instrument.

I-T-E Circuit Breakers are guaranteed to run continuously at their rated capacities without heating more in any part than 20 degrees Centigrade above the surrounding temperature. The question often arises, taking this rate of heating as a basis, what will

be the heating at higher loads? At first sight it might seem proper to assume, as the heat generated in the instrument is proportional to the square of the current, the resistance being practically constant, that the temperature rise will also be in the same proportion; but it must not be forgotten that the rate at which radiation takes place varies with the difference in temperature between the radiating body and that of the surrounding medium. An approximate expression showing the relation between current carried and the resulting temperature rise is given by the equation $\frac{C_2^2 - C_1^2}{2C_1^2} = \frac{T_2 - T_1}{T_1}$ in which T_1 is the temperature rise caused by a sustained current C_1 and T_2 the temperature rise which will result from a sustained current C_2. As an application of the foregoing, suppose that an instrument will carry 100 amperes with a temperature rise of 20 degrees centigrade, what will be the temperature rise if it carries 150 amperes? Substituting in the equation the values of T_1, C_1 and C_2, we have $\frac{150^2 - 100^2}{2 \times 100^2} = \frac{T_2 - 20}{20}$ or $T_2 = 32.5°$.

It is to be understood, of course, that this formula is applicable only within such limits of temperature as will not involve material change in the total resistance of the body under consideration.

Where instruments are not intended to be used continuously at the maximum adjustment, the range may be extended accordingly; but for the average conditions of use, a range of adjustment varying between 75 per cent. of the rated capacity as a minimum and twice that as a maximum provides not only for the satisfactory performance of the instrument, but gives the required flexibility as well. Special conditions may arise which require instruments having a wider range of adjustment than are provided in accordance with the foregoing. Particularly is this likely to be the case with instruments for laboratory work. Wide ranges of adjustment may be obtained in either of two ways: a single instrument may be supplied

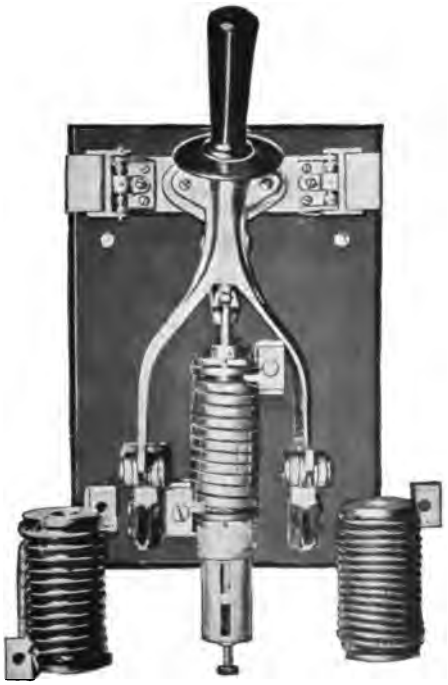


ILLUSTRATION No. 4

with a number of interchangeable coils of varying capacities and providing different ranges of adjustment, or the instrument may be furnished with two fixed coils—one for use in connection with small currents, and a heavier one for large currents.

Cut No. 4 shows an instrument of the first-named class, one of a number furnished in accordance with the requirements of Prof. Owens, of McGill University, Montreal, and now in use in the Electrical Laboratory of that institution.

By the use of three coils a range of adjustment of 40 amperes to 225 amperes is secured. These coils are held in place by means of screws passing into the terminals fixed upon the base, while the plunger, the plunger guide-tube and adjustment stirrup may readily be removed by loosening a single thumb-nut which supports them in their proper position in the magnetic jacket.

The adjusting stirrup, instead of being of the usual shape, is made tubular in form, so as to provide ample room for the calibration scales, corresponding with the three distinct ranges of adjustment furnished by the different coils.

Cut No. 5 shows a double pole instrument provided with two coils in series. The coil on the right is of 80

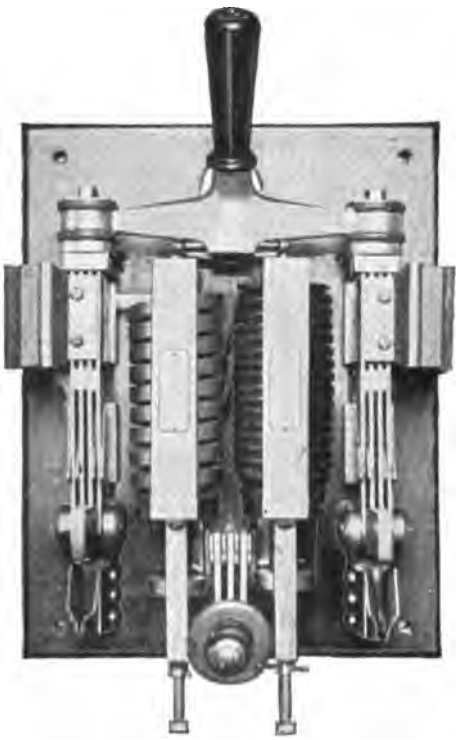


ILLUSTRATION No. 5

amperes capacity and provides a range of adjustment of from 25 amperes to 150 amperes. The left-hand coil is of 600 amperes capacity and has a range of adjustment of from 200 amperes to 1000 amperes. The switch shown at the bottom of the cut serves to short-circuit the coil of small carrying capacity when large currents are being used. Thus a single instrument is made to provide for a range of adjustment of from 25 to 1000 amperes. The one illustrated is used in connection with the generator testing set in the laboratory of the United States Navy Yard, at New York.

The foregoing may serve to illustrate some of the many ways by which the range of the overload instrument has been extended, and the following are offered as suggestive examples of the means by which the scope of application of I-T-E Circuit Breakers has been widened.

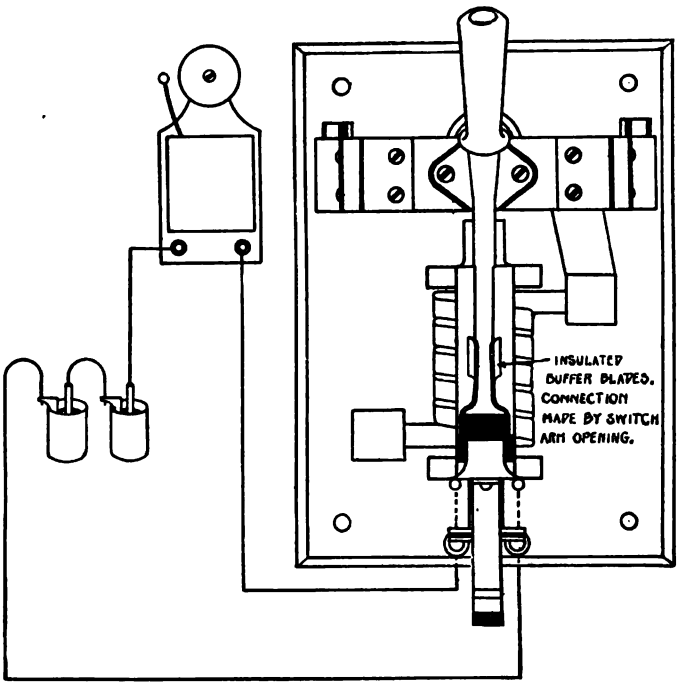


ILLUSTRATION No. 6

In industrial establishments where circuit breakers are used, the necessity frequently arises for some convenient means of indicating the opening of these instruments. Particularly is this need apparent in establishments where the work done is of such a character as to result in noise which obscures the sound incident upon the opening of the circuit breakers. The accompanying cut shows the manner in which an alarm bell or annunciator may be brought into the circuit upon the opening of

the instrument, the only modification necessary in the circuit breaker being the insulation of the buffers from the supporting frame, and providing them with suitable terminals for connection with bell and battery. The accompanying illustration (No. 6) clearly shows the arrangement of the signal circuit.

Another valuable accessory of the I-T-E Circuit Breaker is the **"auxiliary coil."** This, as its name suggests, is a coil for operating the instrument upon special conditions, differing from those dealt with by "Overload," "Underload" or "No Voltage" instruments. This auxiliary coil is of fine wire, of many turns, and of comparatively high resistance. It is normally open-circuited and is adapted to receive the full line pressure of the system with which it is connected. When subjected to this pressure it instantly causes the opening of the circuit breaker. See illustration No. 7.

A number of applications for this coil will at once suggest themselves to the engineer. This feature proves its value where it is necessary to place the switchboard under control from a distance, or where special apparatus must be controlled from a number of points.

Another application is best illustrated by citing a practical case. In one of our large cities in the centre West, the draw-bridge constituting a part of a busy thoroughfare is operated electrically, the equipment being protected by a circuit breaker provided with an auxiliary coil. This coil is automatically brought into circuit by mechanism which moves synchronously with the bridge, so that at certain points in the travel of the bridge it closes the circuit of the auxiliary coil, causing the circuit breaker to cut off the power supply at the proper instant, both upon opening and closing of the draw.

One of the large telephone companies applies the **auxiliary coil** in a very interesting way: instruments supplied with these

coils are used for the protection of the station storage batteries. A polarized relay is also in circuit with the storage battery and serves to bring the auxiliary coil into circuit upon the passage of a predetermined reverse current.

The foregoing instances only suggest the wide range of application of this device. Where the use of this coil is contemplated in the construction of an "Overload" Circuit Breaker, it may readily be enclosed within the main or overload coil, so that it will operate upon the same plunger. To meet cases where the **"auxiliary coil"** is an after-thought, a complete auxiliary tripping mechanism has been designed. This is entirely self-contained and is mounted upon the spring-tube of the instrument; it is readily placed in position and is highly efficient in its action.

A combination of **"insulated buffers"** and **"auxiliary coils"** may be made to serve to cause the opening of one circuit breaker to effect the opening of another circuit breaker at a distance. In this case the opening of the first circuit breaker closes, through the buffers, the circuit of the auxiliary coil of the second circuit breaker in series with the bus bars. This scheme has been used for the protection of motor generating sets.

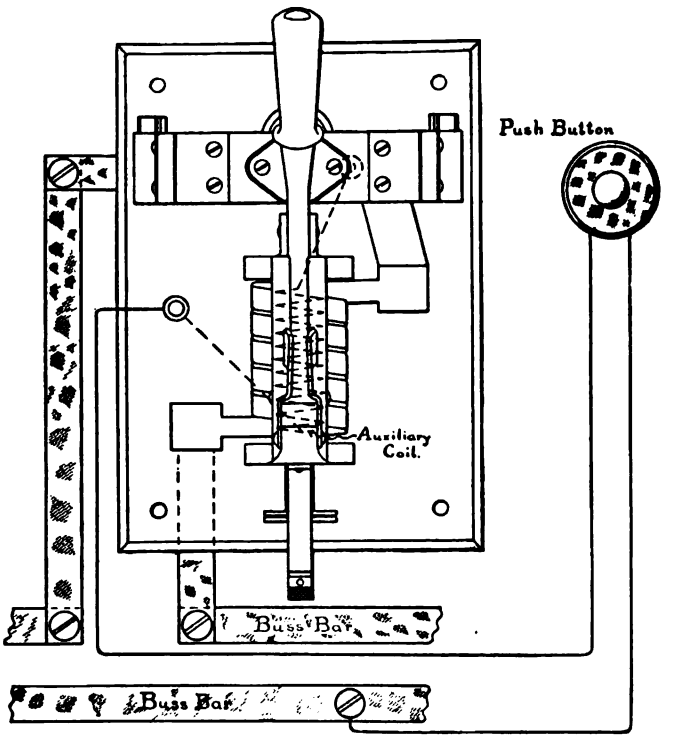


ILLUSTRATION No. 7

ALTERNATING CURRENT CIRCUIT BREAKERS AS LIGHTNING ARRESTERS.

While this is not by any means their most important function, all the testimony on this point suggests their efficiency. The well-known solenoidal principle, upon which the actuating mechanism depends, effects in the device a remarkably low inductance—a feature of importance where high frequencies are used.

Mr. F. M. Tait, Superintendent of the Catasauqua Electric Light and Power Co., in writing, says:

"Your I-T-E Alternating Current Circuit Breakers are giving perfect satisfaction. Those on our Switchboard were very efficient lightning arresters during the past summer."

We also quote from a letter from Mr. Charles B. Hunt, Manager of the London Electric Co., Ltd., London, Ontario:

"Since we put them on our switchboard we have not had a good opportunity of testing them until last evening, when one of the worst thunder-storms that has visited this locality for some time passed over the city. We were very much pleased with the way in which the circuit breakers opened and relieved the pressure from our lines every time the lightning struck them. We think they are going to be quite a success."

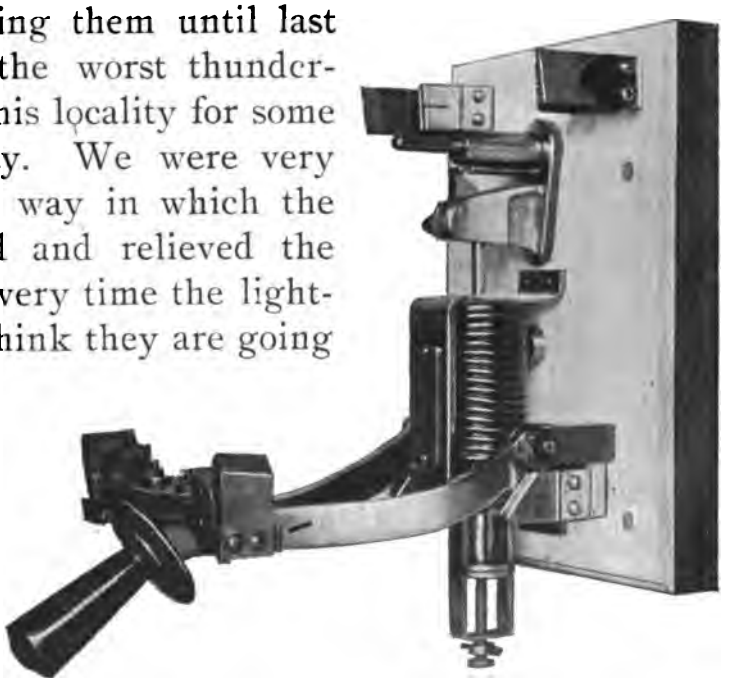


ILLUSTRATION No. 8

Many other similar letters could be quoted, but enough.

In the selection of alternating current instruments, the question

of voltage is one of special importance. The instruments intended for operation on 2200 volts, of capacity from 5 to 60 amperes, are made on a larger and heavier scale than instruments of the same capacity for lower voltage, thus permitting a wider separation of the terminals and a longer break. The accompanying illustration, No. 8, clearly shows the clean, wide break obtained in the I-T-E Circuit Breaker.

Instruments of from 80 to 200 amperes capacity at 2200 volts are made with the terminals insulated by means of hard rubber from the supporting base and switchboard, thus insuring against the effects which might otherwise result from the rupture of the current at this voltage.

Alternating current instruments are invariably mounted on marble bases, thus avoiding the possibility of metallic veins, which may occur in slate bases.

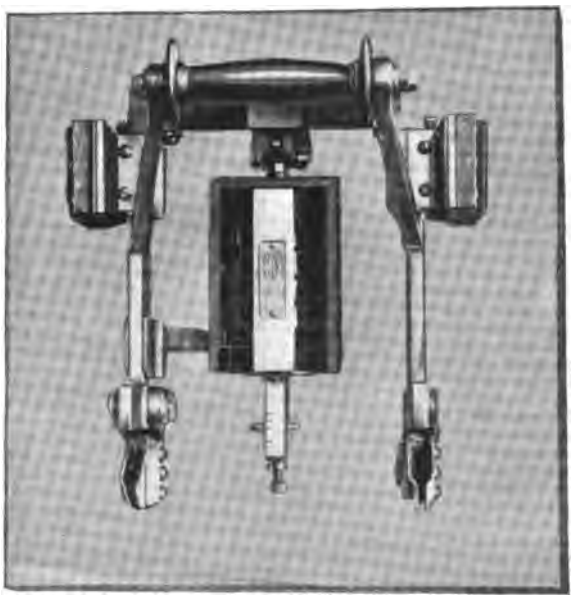


ILLUSTRATION No. 9
I-T-E CIRCUIT BREAKER
DOUBLE POLE, FOR 1100 VOLTS AND UNDER

ELECTRICITY IN THE BAROMETER OF TRADE.

The late Jay Gould referred to Iron as "the barometer of trade." Gibbon, the famous historian, more than one hundred years ago, in speaking of the Roman Empire, said: "The command of Iron soon gives a nation the command of Gold." If this was true in the time of the Romans, how much more true is it to-day! Mr. Andrew Carnegie is a glittering example of the truth of Gibbon's statement.

It is in a great measure to Iron, in one form or another, that we owe the position that we occupy in the markets of the world. Our interest, however, is not in Iron or Steel in themselves, but in their manufacture and in the important part which Electricity has come to play in that manufacture; and we are especially interested in all of the apparatus which increases the output of a shop or mill or which reduces the cost of a given output. Not only has the use of Electricity reduced the cost of production, but it has made possible such prompt deliveries that our good friends, the English, attribute our success in this direction to "pull" or to Yankee smartness. Does not our "smartness" chiefly consist in studying carefully the cost of every item and applying the best and latest methods to every detail of manufacture? Mr. Chas. T. Yerkes says: "The English do not know the value of the scrap heap." Our policy, briefly stated, is to do the best we can as quickly as we can, and to employ every known method, no matter how small or seemingly insignificant.

The visitor to any of our large iron or steel mills is perhaps most of all interested in the electric equipment. The power-house is often of many thousand horse-power capacity; amazed—stunned as it were—by their magnitude, he is almost immediately struck by the comparatively few men who are operating these immense works. Electricity has reduced the number of men necessary to a given operation and increased their output. It is a wonderful sight to see a gigantic electric crane glide quietly and rapidly down the length

of an enormous building, stop right over an oven, the door of which is thrown back, and a pair of tongs descend from the crane, catch hold of an ingot weighing many tons, lift it and convey it to the rolls (also operated by Electricity), where it is immediately transformed into a beam or plate. Formerly the work performed before the visitor's eye was done by a slow, expensive process, employing hundreds of men in an exhausted condition, owing to the intense heat; to-day, one man standing in an enclosure at some distance from the actual operation, is controlling all of the various motors that are required for operating this almost human mechanism. There is speed without confusion; no hitch occurs, and yet the immense power back of these machines is all perfectly controlled and acting, as it were, automatically.

To the casual observer, all that is required to operate these huge machines by Electricity is the current itself and means for applying and cutting off the same; but with these alone a plant would soon be in trouble; burnt-out motor or generator armatures would be the rule rather than the exception, for these machines are frequently subjected to enormous overloads, and the best apparatus manufactured could not withstand these sudden strains. At this point the **I-T-E Automatic Circuit Breaker** comes into use. This apparatus is designed to protect motors and generators from these sudden inrushes of current, automatically opening the line when the current exceeds a pre-

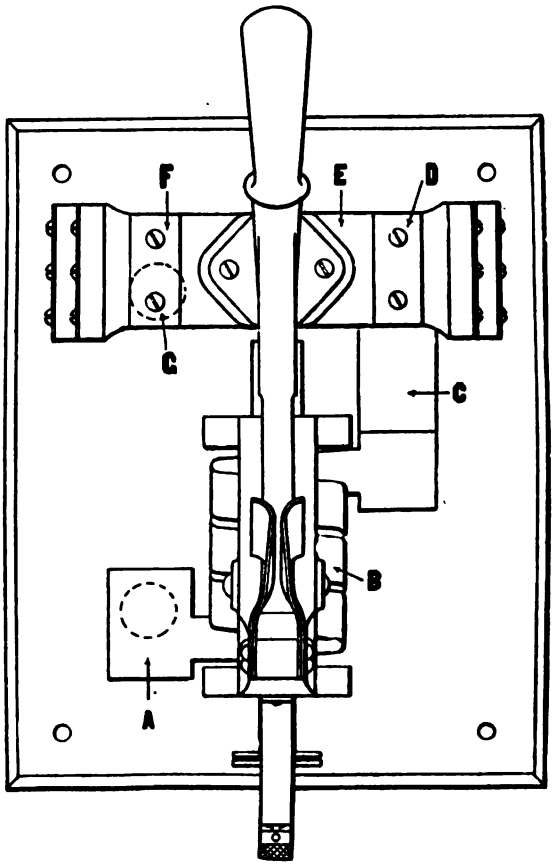


ILLUSTRATION No. 12

FRONT VIEW of the I-T-E Automatic Circuit Breaker, indicating the path of the current and the operation of the instrument.

determined danger point. The I-T-E CIRCUIT BREAKER is particularly well suited for such work, owing to its careful design, its simplicity in operation and its mechanical strength. Primarily it is a switch that opens automatically, and it has frequently been spoken of as "an electric safety-valve."

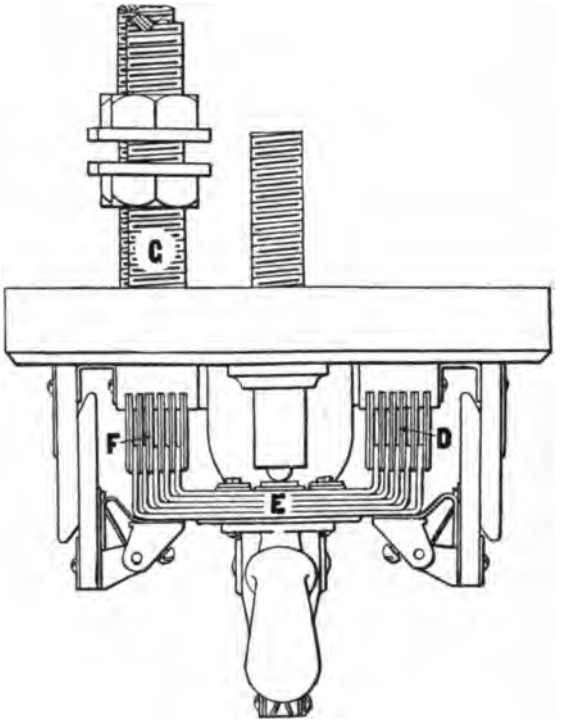


ILLUSTRATION No. 13

TOP VIEW I-T-E Automatic Circuit Breaker, indicating the path of the current and the operation of the instrument.

Illustration No. 12 shows a front view of this device. The current in the circuit enters at "A," passes through the solenoid coil "B" (which in its iron jacket becomes a powerful magnet) through the copper terminal "C" to the contact blades "D," across the bridge at "E" to the contact blades "F" and out into the line at "G." The path of the current as indicated above can perhaps be better understood by reference to illustration No. 13, which gives a top view of the instrument.

When the current in the solenoid coil produces sufficient magnetism to overcome the weight of the plunger, this plunger is drawn up with constantly increasing velocity until it strikes a restraining latch or trigger, which forces the arm out of the switch, thus automatically opening the circuit. These instruments can be made to open at any current value and they open the circuit the instant the current reaches any predetermined limit. The copper contacts are separated and the carbon contacts are so designed that the arc caused by the opening of the circuit under full load is broken on these carbons, and the copper contacts are thus entirely protected from the effects of the arc.

In every plant of importance Circuit Breakers have entirely superseded the use of the now antiquated fuse, which formerly was thought to afford the necessary protection. Not only do I-T-E Circuit Breakers protect the motors, generators and apparatus generally from the effects of an overload or short-circuit, but they also result in great saving of power in the generating plant. Mr. Richardson, the distinguished Electrical Engineer of the American Bridge Co., in speaking of the I-T-E Circuit Breaker, said:

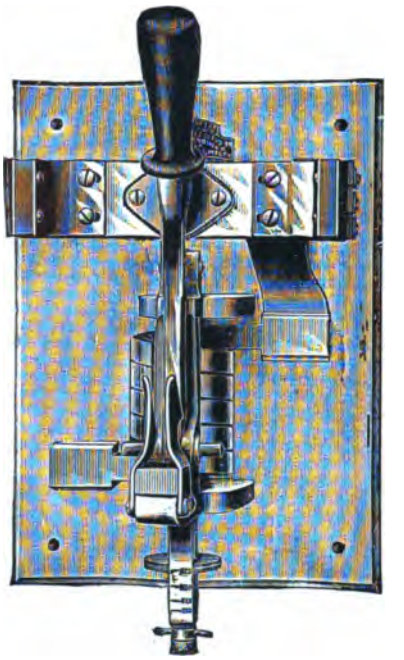


ILLUSTRATION No. 14

"We have more than fifty electric cranes equipped with I-T-E Circuit Breakers which it would now be almost impossible to work without them. They are giving us very good satisfaction, especially in saving power at the power station. For instance, we have at present connected there 200 motors of a rated capacity of 2,500 H. P., while our generator capacity is only 375 H. P. I think the introduction of your I-T-E Automatic Circuit Breaker in our plant has been of great benefit to us."

This was several years ago, since which time the capacity of this plant has been many times increased, and I-T-E Circuit Breakers have not been forgotten.

ILLUSTRATION No. 15

The most popular type of Circuit Breaker for motor protection is the STANDARD SWITCHBOARD instrument, illustration No. 14. This type has a normal capacity of from 80 to 1,000 amperes, the normal capacity of each machine being fixed, but susceptible of an adjustment of from 25% below to 50% above its actual or normal rating. Smaller instruments are provided for smaller motors (see illustration No. 15), known as the

ILLUSTRATION No. 16

MIDGET SENIOR type; these instruments have a normal capacity of from 5 to 300 amperes, and are susceptible of the same adjustment as given for the Standard Switchboard type.

Single pole instruments are perhaps more generally used, being connected in series with the positive wire between the starting-box and the switch. For generator protection Double Pole Circuit Breakers are frequently used, as they disconnect the generator from both sides of the line, and render impossible any danger from lightning and stray currents. Illustration No. 16 shows a double pole instrument of the Standard type, while illustration No. 17 shows an instrument of smaller capacity.

The use of the I-T-E Circuit Breaker prevents injury to apparatus due to unskilled handling. The only thing to be borne in mind is that the Circuit Breaker must be closed before the switch is thrown, so that in case of overload or short-circuit the instrument will immediately open. Where the switch is closed first and the Circuit Breaker afterwards, the result has sometimes been surprising, not to say unpleasant to the attendant.

In a large plant, such as the Jones & Laughlin Co., of Pittsburg, where there is more or less complex system of wiring required, in order to insure having the Circuit Breaker connected on the positive wire, and to protect both wires from an overload, **Double Pole, Double Coil I-T-E Circuit Breakers** are used. These instruments have two operating coils, one connected in series with each wire of the circuit,

ILLUSTRATION No. 17

ILLUSTRATION No. 18

and in case of an overload affecting either wire, or both, the breaker is instantly opened and the motor entirely disconnected from the circuit. For instruments of this type see illustration No. 18.

But it is not from overload alone that the I-T-E Circuit Breaker affords protection. If from any cause the generator of one of these large plants shuts down, or a feeder switch is accidentally opened, the motors stop, and when the generator is again started, or the switch closed, the resistance being all cut out at the starting-boxes, the motor armature will be short-circuited. To overcome this danger (and it is a very common one), an I-T-E Circuit Breaker has been designed to open automatically in case of "no voltage" on the line, so that when the circuit is closed, or the generator started up, the motors will all have been disconnected from the line by the Circuit Breakers having opened automatically, and a short-circuit of the motor armatures thereby prevented. An instrument of this type is shown in illustration No. 19.

A prominent engineer recently remarked: "The steel industry presents very similar electrical problems to the street railway, with its constantly changing loads. As a large motor or tool or crane is put into operation, at times the peak of the load becomes very great and the next instant the load may be reduced to almost nothing."

ILLUSTRATION No. 19

The application of the storage battery to such a plant not only takes the strain due to these loads off of the generator, but admits of a smaller generating plant, the storage battery

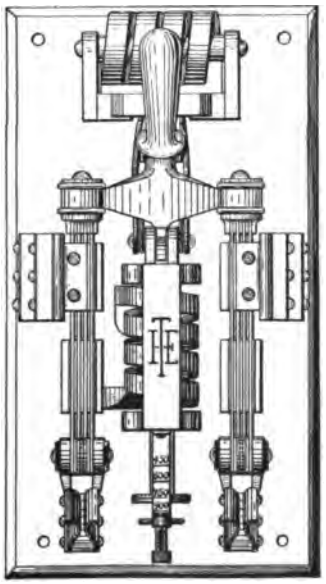


ILLUSTRATION No. 20

charging during these moments of light load, and discharging or carrying part of the load during a period of heavy load. Here again an I-T-E Circuit Breaker is required, and the OVERLOAD and UNDERLOAD types are specially designed for such storage battery work. (See illustration No. 20.)

If the battery is placed in multiple with the line (as on a street railway), the plain OVERLOAD Circuit Breaker is all that is required, but if the battery is charged in series with the line, a Circuit Breaker actuated by UNDERLOAD is needed to prevent the battery discharging and running the dynamo as a motor, in case the voltage of the latter should drop below the voltage of the battery, due to the dynamo slowing down.

In brief, every required protection can be secured by the use of one type or another of the I-T-E Circuit Breaker. Its scope of usefulness is almost unlimited, and the size of the instruments required is constantly increasing. Thus the great Illinois Steel Company, of Chicago, through its Electrical Engineer, Mr. E. B. Clark, has recently installed a large number of I-T-E Circuit Breakers, among them an instrument of 5,000 amperes capacity, such as shown in illustration No. 21. This type is made up to 7,500 amperes capacity.

ILLUSTRATION No. 21

On account of the incessant noise in rolling mills, and in fact in all parts of a steel plant, the engineer in charge is likely to overlook the opening of a Circuit Breaker, which may cut out an entire shop from the power plant. In order that he may be instantly apprised of the opening of a Circuit Breaker, a small, inexpensive attachment has been devised. This consists of a pair of insulated buffers. The opening of the Circuit Breaker closes a local circuit, which operates a signal or annunciator, as may be best adapted to the peculiar requirements. This has already been illustrated by a diagram in our "I-T-E Circuit Breaker Practice, No. 2."

We have endeavored briefly to suggest some of the most common uses of the I-T-E Circuit Breaker in an industry which is the pride of our country, but there are many other uses which will suggest themselves to the electrician in charge of every isolated plant. Scarcely an industry of importance but has its own electric equipment, for what is true of one plant is true of another, to a very great degree. We have all the same ambition; we are all striving to increase our output and to diminish its cost. The power which has enabled the rolling mill to accomplish this is equally efficient and equally to be desired in almost every other manufacturing industry. The great newspaper, printed on Hoe presses, is driven by electricity and safeguarded by I-T-E Circuit Breakers. The Public Printing Office of the United States Government, at Washington, which, when completed, will be the largest and best equipped plant of its kind in the world, will be operated entirely by electricity, and in its electrical equipment the I-T-E Circuit Breaker will occupy no mean position. Mr. W. H. Tapley, the Electrical Engineer in charge of this immense power plant, stated in one of the electrical papers some time since, that it was only upon the advent of the modern Circuit Breaker that protection worthy of the name was secured for motor-driven machinery, and he forcibly illustrates the fact that protection is needed, not alone to the motor, but to the machine driven by it, the relative value of

a printing-press being ten times that of its motor, which justifies his statement that "the protection of the machinery must not be lost sight of."

When it is realized that the I-T-E Circuit Breaker protects both motor and machinery, it will be readily seen that ideal protection is obtained.

Our large shipyards, which are building battle-ships which are accepted as models of their class, employ the same power, protected by the same apparatus, for driving their machine tools. Cramps' Shipyard of Philadelphia, the electrical equipment of which is in charge of Mr. Chas. J. Dougherty, has been frequently described, as has the electrical equipment of the Union Iron Works of San Francisco, in charge of Mr. W. W. Hanscom, their Electrical Engineer.

The I-T-E Circuit Breaker has its important place in the big fighting machines recently constructed for the United States, the Russian, and the Japanese navies. These marine equipments will be described in another number.

Through the courtesy of Mr. F. L. Stevenson, the electrical engineer of the Deering Harvester Co., we are enabled to illustrate the switchboard recently installed in their plant in Chicago. Its beauty is apparent, and it only remains to describe it briefly. It is 47 feet long, and 7½ feet high, composed of twenty panels of blue Vermont marble. The system employed is 600 volts, three-phase alternating current operating both induction and synchronous motors. This entire electrical equipment was fully described in the "American Electrician" for August, 1900, under the heading "The Largest Isolated Plant of Induction Motors in the World."

It would not be possible—at least it would not be profitable—to further enumerate in detail the large plants throughout this country using I-T-E Circuit Breakers. Their number is constantly increasing as the value of this apparatus becomes better understood. As has been said, "The ultimate requirements of a Circuit

Breaker are that we can rely upon it to do all that we have shown it should do, and operate successfully, not once, twice, or for a month, but always. To produce such an instrument the highest skill, electrical and mechanical, is required. Long study of the existing state of the art and the conditions under which Circuit Breakers are called upon to operate are necessary, and the closest attention must be given to every detail of their manufacture."

THE CUTTER COMPANY feels that the I-T-E CIRCUIT BREAKER manufactured by them entirely fills these requirements. More than eighteen thousand (18,000) sizes and types are listed or suggested in their published catalogues, and special instruments to meet special conditions are always in building. They refer, without permission, but with pardonable pride, to a few important users of I-T-E CIRCUIT BREAKERS in addition to those already mentioned:

The Carnegie Steel Co., Pittsburg, Pa.
The American Steel Castings Co., Alliance, Ohio.
National Steel Co., Keystone, Ohio.
The Granite City Steel Co., Granite City, Ill.
The Lorain Steel Co., Lorain, Ohio.
Bridgeport Brass Works, Bridgeport, Conn.
Midvale Steel Co., Philadelphia, Pa.
Maryland Steel Co., Sparrows Point, Md.
Pennsylvania Steel Co., Steelton, Pa.
American Tin Plate Co., New Castle, Pa.
The Richmond Locomotive Works, Richmond, Va.
National Tube Works, McKeesport, Pa.
New Jersey Zinc Co., Hazard, Pa.
Baltimore Copper, Smelting and Rolling Co., Baltimore, Md.
Pullman Parlor Car Co., Chicago, Ill.
The Vulcanite Portland Cement Co., Phillipsburg, N. J.
The Atlas Cement Co., Northampton, Pa.
United States Steel Corporation.
The National Cash Register Co., Dayton, Ohio.
The Gould Coupler Co., Depew, N. Y.

Link Belt Engineering Co., Philadelphia.
J. P. Mathieu, Kid Factory, Philadelphia.
Stetson's Hat Factory, Philadelphia, Pa.
"San Francisco Examiner," San Francisco, Cal.
Armour & Co., Chicago, Kansas City and Omaha.
Cudahy Packing Co., Kansas City, Mo.
Cotton Oil and Fibre Co., Norfolk, Va.
Anaconda Copper Co., Anaconda, Montana.
Pennsylvania Railroad Co.
New York, New Haven and Hartford Railroad Co.
New York Central Railroad Co.
Metropolitan Street Railway Co., New York.
Metropolitan Street Railway Co., Kansas City, Mo.
Metropolitan Street Railway Co., Chicago, Ill.
Metropolitan Underground Railway of Paris.
Montreal Street Railway Co., Montreal, Canada.

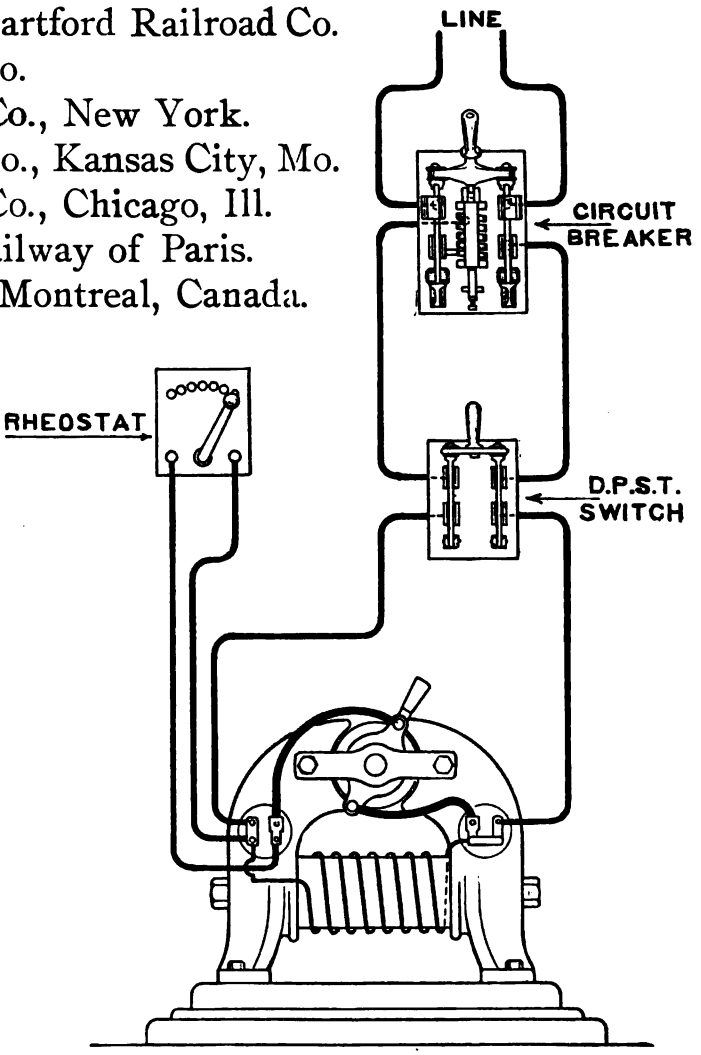


ILLUSTRATION No. 25

Diagram showing connections of double pole I-T-E Circuit Breaker, as used to protect motor from overload and short circuit.

THE I-T-E CIRCUIT BREAKER IN THE STREET RAILWAY FIELD.

The importance of the Circuit Breaker in Street Railway work is conceded. It affords a protection which is instant, ample and inexpensive. The question as to the advisability of using Circuit Breakers has long since been decided, and it only remains for engineers and manufacturers to discuss the merits of the several types now on the market. To do this dispassionately is perhaps not always to be expected of the manufacturers.

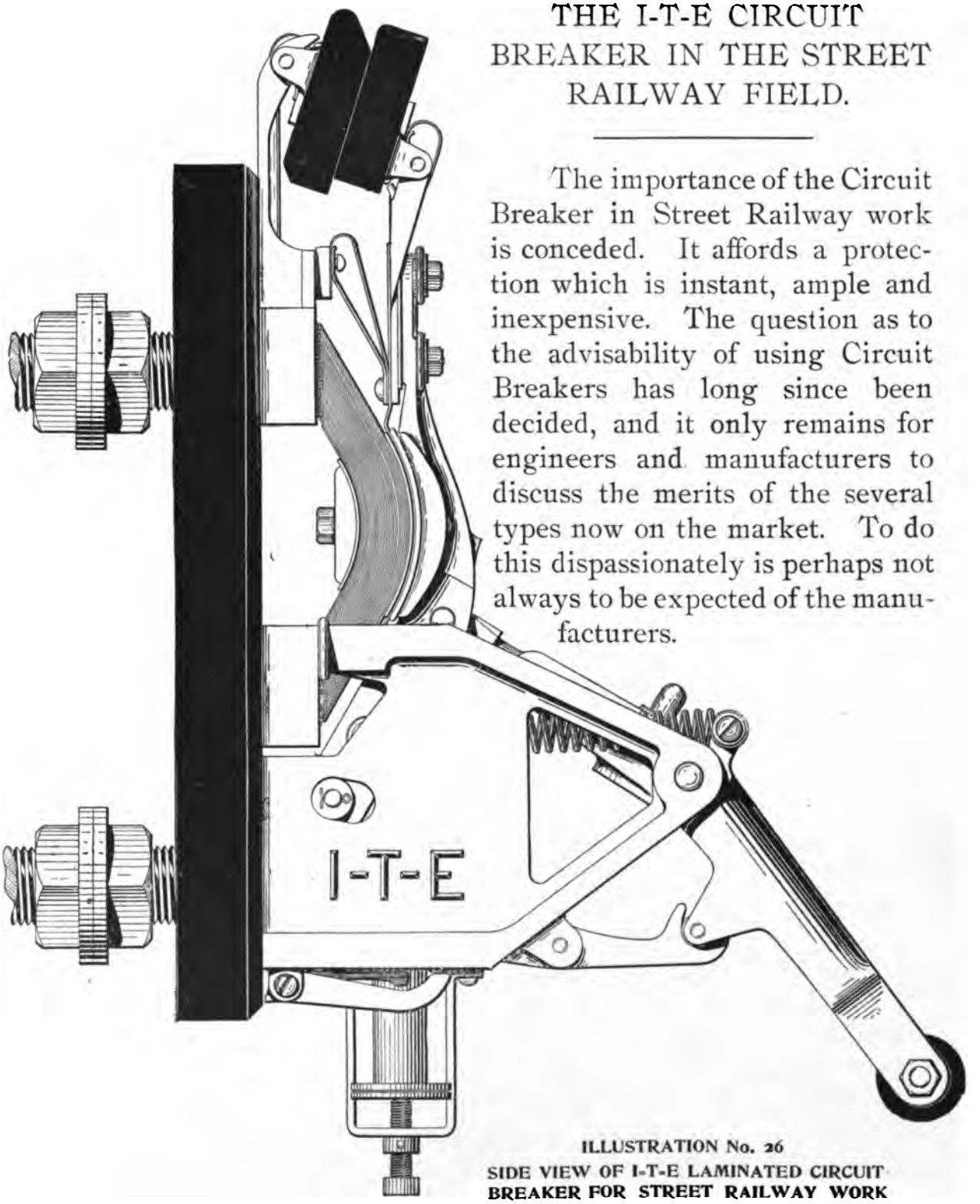


ILLUSTRATION No. 26
SIDE VIEW OF I-T-E LAMINATED CIRCUIT BREAKER FOR STREET RAILWAY WORK
7500 Amperes Capacity

For obvious reasons it is a field difficult to enter. Immense difficulties have to be overcome. Especially is this the case in introducing to the attention of the General Manager or Engineer of an important Street Railway a comparatively small piece of apparatus at a time when his mind is fully occupied with the question of generators and equipment; yet it is just at this time when the question of the protection to his apparatus should be uppermost in his mind, for the apparatus to be protected is costly and easily damaged.

For the past seven years we have devoted practically our entire attention to the manufacture of I-T-E CIRCUIT BREAKERS of every possible size and type. During this time we have consistently maintained that the final arc should be broken upon carbon. In this we have been opposed; but recently the manufacture of competitive apparatus on lines somewhat similar to our own leads us to believe that the strength of our argument is admitted.

We have several thousand knife-blade instruments, of capacities up to 1500 amperes, working satisfactorily on important street railways all over the United States, Canada and Europe. Nevertheless, we have never been entirely satisfied that this type of Circuit Breaker, especially in large sizes, was the best that could be produced. For the past two years we have been at work upon a Circuit Breaker which would overcome all criticism, carefully studying the conditions under which it has to operate, and profiting not only by our experience, but that of our competitors, both in this country and abroad.

Having instituted so many important developments, and being the originators of such a large number of entirely new types, it was but natural that engineers should look to the makers of the I-T-E CIRCUIT BREAKER for an instrument in which all objections should be overcome. As has been stated, we have maintained that the final arc should be broken on carbon. We have also believed that all current-carrying parts should be in plain sight, easily under

the eye of the switchboard attendant. The instrument should also be instant in operation, easily reset, and capable of being placed either at the top or bottom of the switchboard.

In presenting (see illustration No. 26) the I-T-E LAMINATED CIRCUIT BREAKER, built for direct current in capacities up to 7,500 amperes, and for voltages of 750 or less, we wish to call attention to the following features.

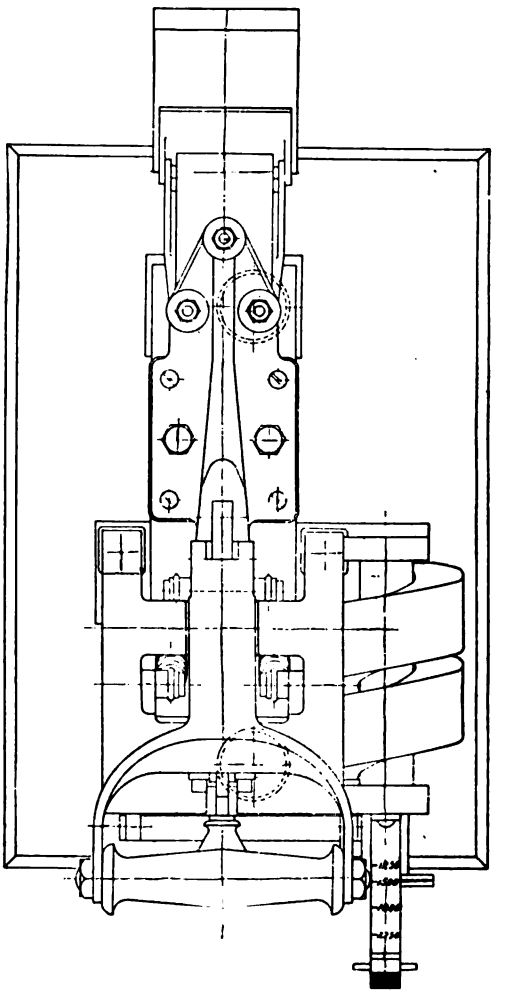


ILLUSTRATION No. 27
Front view I-T-E Laminated Railway Type. 1500 Amperes, normal rating.

FIRST. The shunt circuit is entirely non-inductive; this feature renders it easy for the current to be diverted from the main bridge to the shunt circuit, and renders impossible any arcing upon the main contacts.

SECOND. The breaking parts are all in plain view and easily removed and replaced, while the adjustment can be easily changed by the turn of a thumb screw.

THIRD. The main bridge, as mounted upon the switch-arm, is insulated from the shunt circuit. In the act of opening, therefore, the bridge is first brought entirely out of circuit prior to the opening of the shunt circuit, thus rendering unlikely the bringing of the bridge into circuit again by the expansion of the arc, due to the final breaking. This action is further secured by the peculiarly constructed slot in which the main switch-arm pivot moves, permitting a parallel movement of the two ends of the bridge in opening.

FOURTH. Free preliminary movement of the armature, which operates upon the trigger. In the opening of the Circuit Breaker, therefore, the trigger is actuated by a hammer blow, rendering the adjustment of the Circuit Breaker free from the influence of friction. It is, in fact, governed entirely by two constant forces—gravitation and mechanism.

FIFTH. The construction of the instrument is such that no parts of the frame are in circuit, whether the instrument is open or closed.

SIXTH. The construction of the *laminated bridge* is such as to provide contact of the least possible resistance. These contacts are ground into form by a process which we believe is employed only by ourselves, and which insures perfect results.

SEVENTH. The instrument is practically self-contained, and for this reason may be transferred from one panel to another, or remounted as may be required, without the necessity of unusually skilled mechanics.

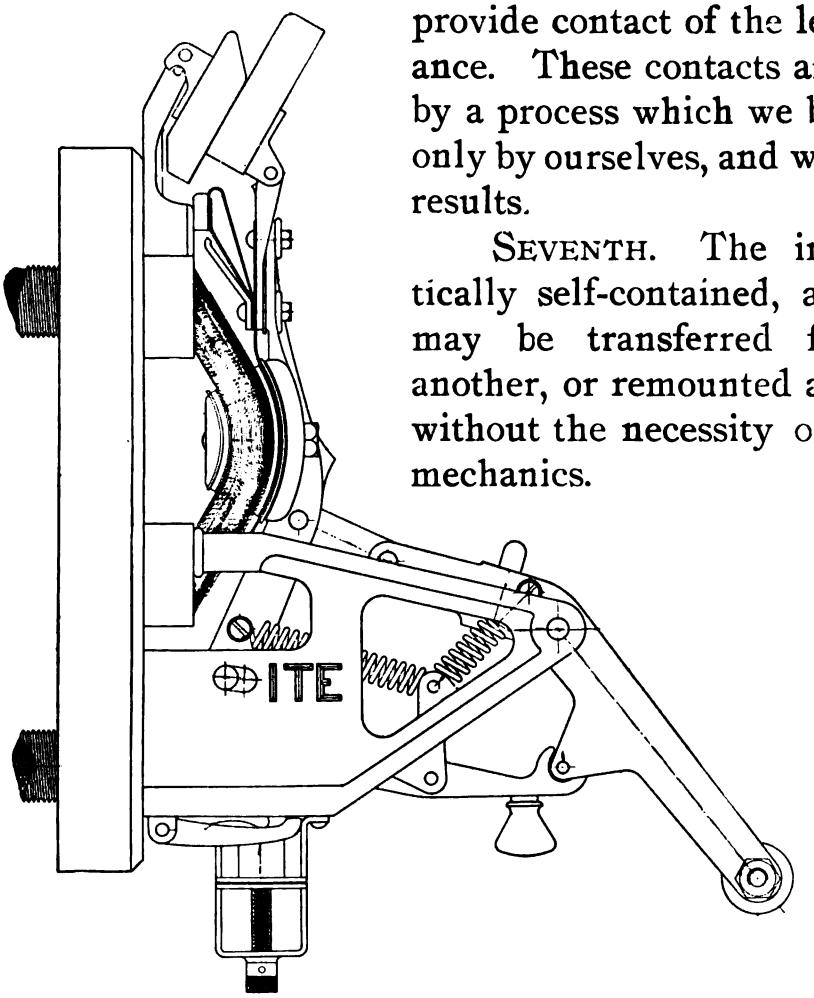


ILLUSTRATION No. 28
Side view I-T-E Laminated Railway Type. 1500 Amperes, normal rating.

The principle of the I-T-E CIRCUIT BREAKER, to which the merit of this instrument is largely due, has been many times explained, and yet the fact that we are still asked, "What does I-T-E mean?" suggests to us that a fuller explanation

may not be out of place. "I-T-E" stands for "*inverse time element,*" which might be defined in several ways: That in *inverse* proportion to the current is the *time element* of action; which is, the heavier the current, the quicker the action; or, the greater the danger or necessity, the quicker the relief; or that the time of opening the circuit becomes less and less as the conditions of the circuit protected approach nearer and nearer a short-circuit. In other words, *it is the principle that makes circuit breakers practical.*

We believe that where merit alone is considered, the I-T-E LAMINATED CIRCUIT BREAKER will invariably be used. Tests recently made, not only in this country, but abroad, have convinced us of the all-round superiority of this instrument over any other machine now on the market.

In the important matter of price, we believe that these instruments are, value for value, cheaper than any other machines which have ever been built. The large independent companies, whose apparatus is excelled by none, such as the Bullock Electric Mfg. Co. of Cincinnati, Ohio, the Crocker-Wheeler Co. of Ampere, N. J., the Stanley Electric Mfg. Co. of Pittsfield, Mass., are specifying and using these instruments on all of their **important** contracts.

In addition, we have recently installed instruments of this type up to 5000 amperes capacity upon the Metropolitan West Side Elevated of Chicago, the Metropolitan Street Railway Co. of New York, the Metropolitan Underground Co. of Paris, France, the Metropolitan Street Railway Co. of Kansas City, Mo., the Union Traction Co. of Philadelphia, Montreal Street Railway Co. of Montreal, Canada, the Brooklyn Heights Elevated Railway Co. of Brooklyn, and they have also been specified in some of the most important railway work now under construction.

The accompanying illustration, No. 29, shows an instrument designed for the protection of motor-generating apparatus for booster work. The instrument consists of one double pole switch

and one single pole circuit breaker. The switch is so arranged as to be opened by the opening of the circuit breaker. The circuit breaker itself is placed in the circuit of the motor side of the outfit. The double pole switch, the two poles of which are located at opposite ends of the tablet, controls the circuits of the two boosters. In the system in connection with which this apparatus is used, both positive and negative wires are insulated from ground, and one booster is in connection with each side of the line. It will be seen that the operation of the instrument renders it impossible for the circuits of the boosters to remain closed after the circuit of the motor operating them has been interrupted by the circuit breaker. Disastrous effects, likely to follow from the currents feeding back through the boosters, are thereby avoided.

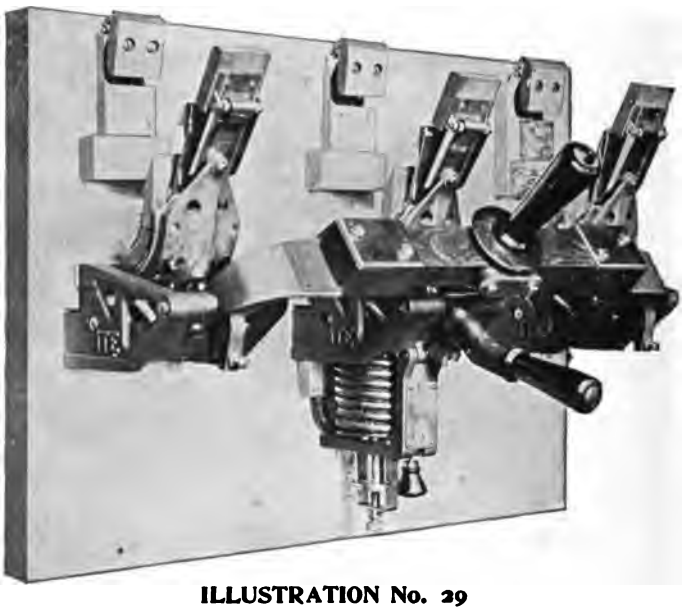
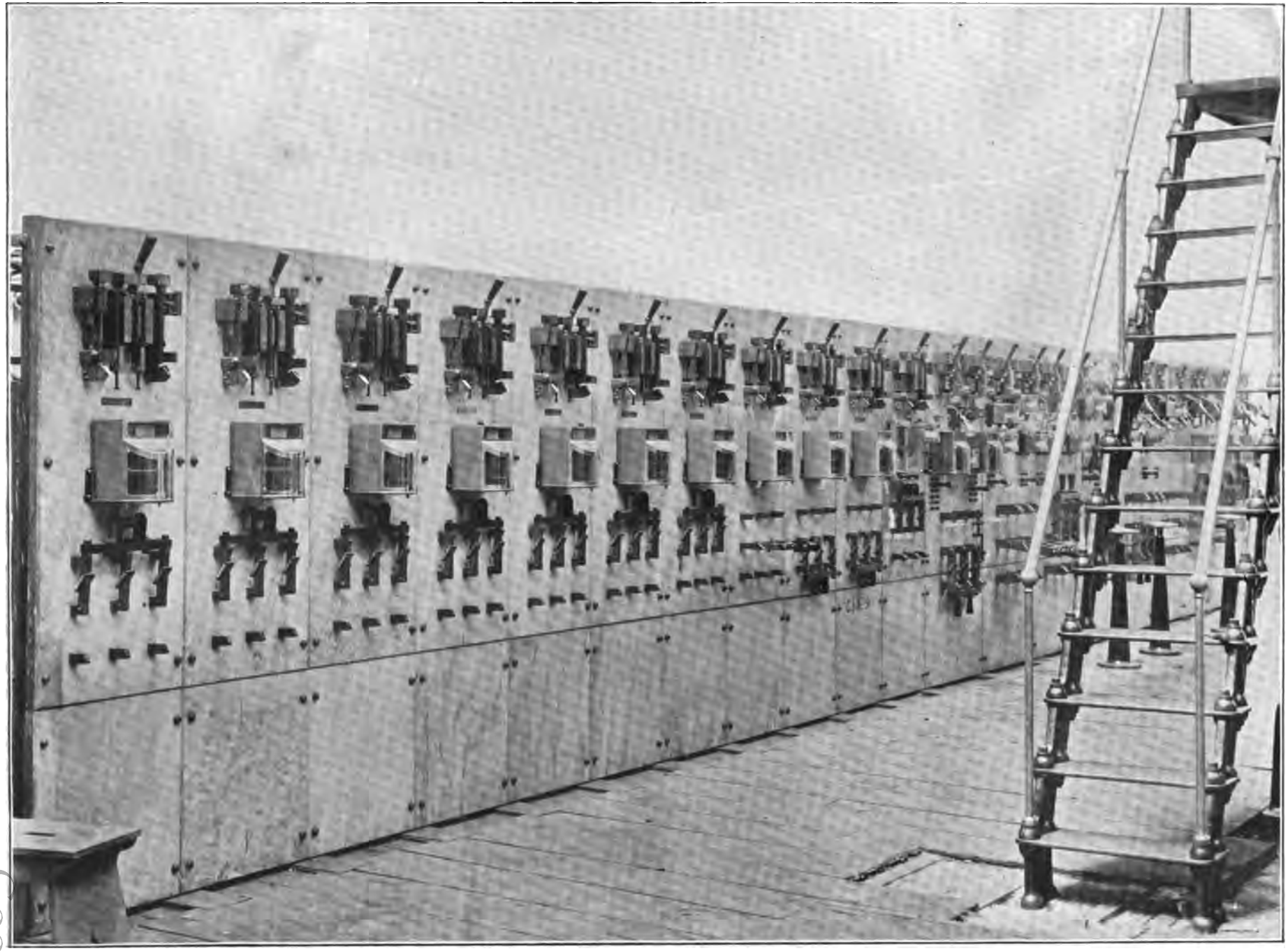


ILLUSTRATION No. 29

Designed by the Cutter Company for Robert W. Blackwell & Company, Ltd., London, New York and Paris.

OVERLOAD AND REVERSAL

We were the first to design instruments of this type, fully appreciating the dangers to which generators running in parallel are subjected. This subject will be fully taken up in another place.



SWITCHBOARD OF THE DEERING HARVESTER CO., OF CHICAGO, ILL.
THREE-PHASE 600 VOLT INSTALLATION

ALTERNATING CURRENT I-T-E CIRCUIT BREAKERS.

The use of alternating current for lighting work, and its recent wide application for power transmission and distribution, has very naturally created a demand for the necessary protective devices. In order to meet this demand, we have perfected through a series of years a number of types of Alternating Current Circuit Breakers which meet successfully almost all of the conditions for which the alternating current is employed. Illustration No. 36 shows an instrument which is much in favor with managers and engineers of electric light stations employing single phase alternating current. It is made in capacities of 200 amperes or less, and is adapted for any voltage up to 2200. The terminals are separated by an ample distance and the wide movement of the switch arm makes it impossible for the arc to "hang fire" upon the opening of the instrument, even upon the occurrence of the severest conditions.

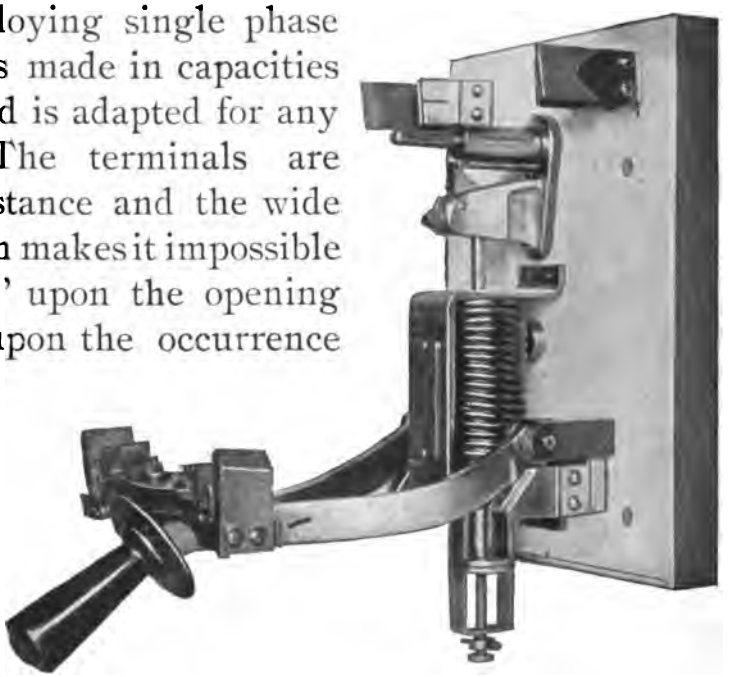
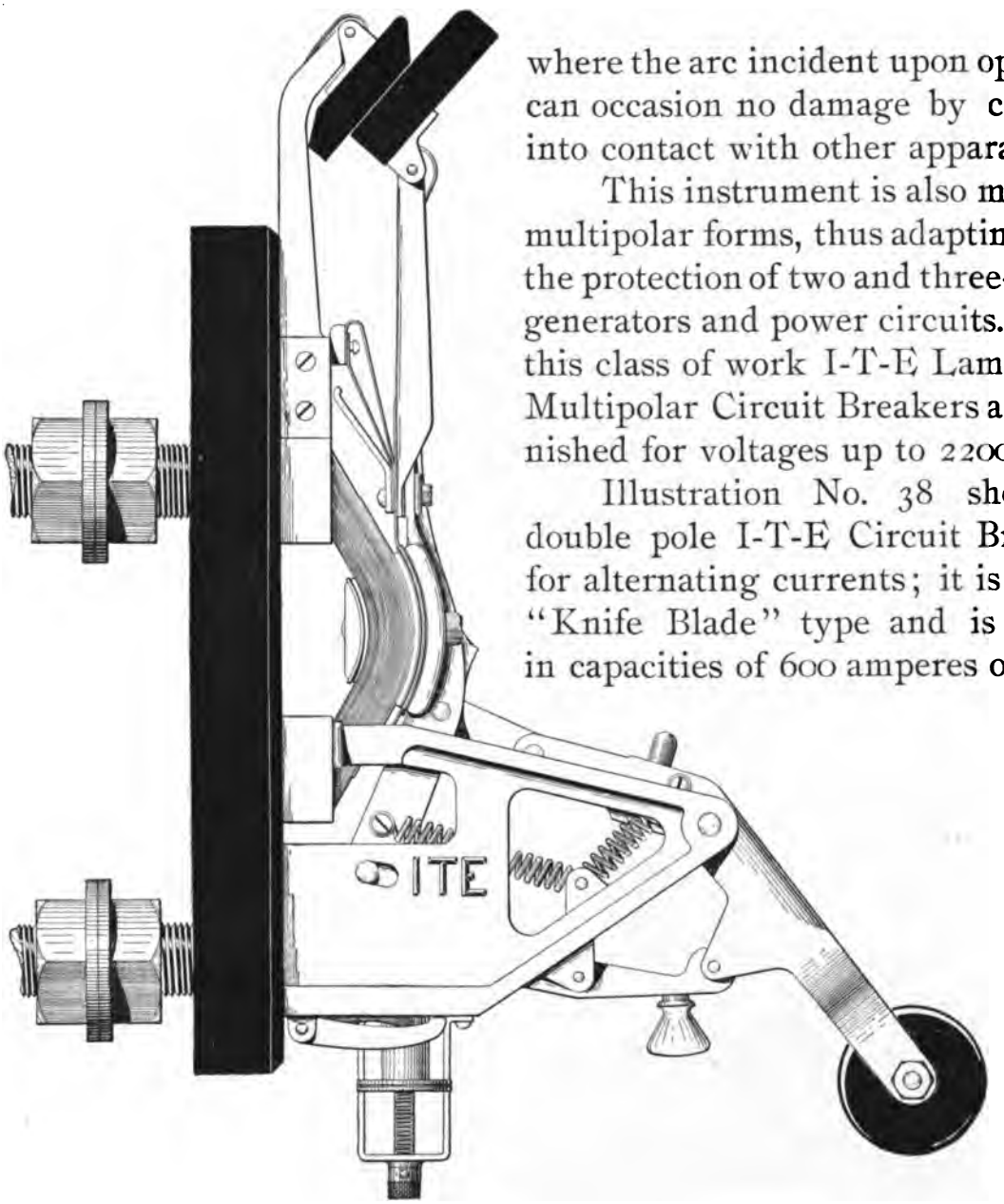


ILLUSTRATION No. 36.

The demand for a protective device for units of larger size at 2200 volts is met by a specially designed type of the "I-T-E Laminated," made at present for this work up to 1500 amperes. As will be seen by reference to illustration No. 37, the auxiliary contacts are carried high above the main terminals; thus at the same time localizing the arc at breaking, and giving a degree of movement to the switch arm which absolutely insures the rupture of the arc, while the position of the handle and the downward movement used in closing permits the instrument to be placed at the top of the switchboard,



where the arc incident upon opening can occasion no damage by coming into contact with other apparatus.

This instrument is also made in multipolar forms, thus adapting it to the protection of two and three-phase generators and power circuits. For this class of work I-T-E Laminated Multipolar Circuit Breakers are furnished for voltages up to 2200.

Illustration No. 38 shows a double pole I-T-E Circuit Breaker for alternating currents; it is of the "Knife Blade" type and is made in capacities of 600 amperes or less,

ILLUSTRATION No. 37. 2200 VOLT TYPE.

and for any voltage up to 1100. The two poles are very carefully insulated one from the other, and the operating handle so located that the operator is free from danger of coming into contact with live parts in closing the instrument.

Illustrations Nos. 39 and 40 show I-T-E Circuit Breakers particularly adapted to the protection of two and three-phase circuits,

generators, or individual motors. The instrument shown in illustration No. 39 is of the "Knife Blade" type; having two coils, it will respond to an overload in either phase of the circuit. Cut No. 40 is a Circuit Breaker of the "Laminated" type and is also provided with two coils; it is triple pole and thus provides for the complete severance of three-phase circuits. The frontispiece is an illustration of the power switchboard of a large manufacturing plant employing three-phase current. The feeders are all protected by double pole, double coil I-T-E Circuit Breakers; the earlier installation shown at the left of the cut being of the "Knife Blade" type, the later of the "Laminated" pattern.

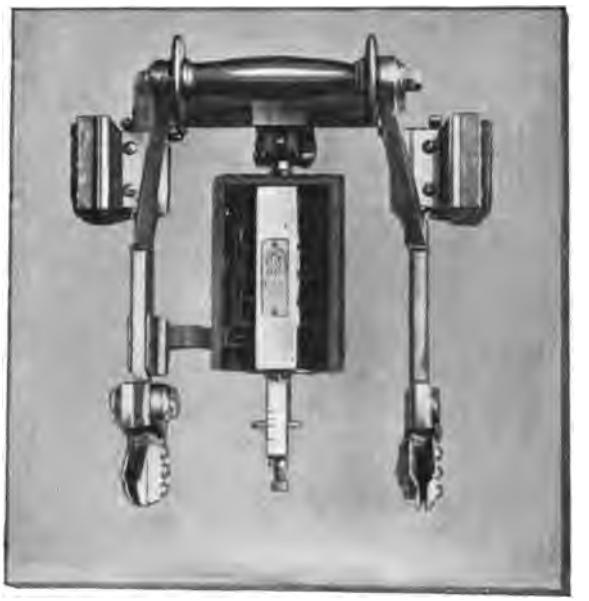


ILLUSTRATION No. 38.

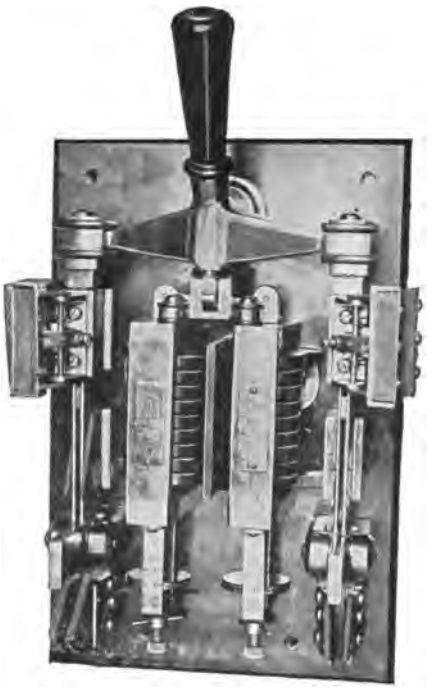


ILLUSTRATION No. 39.
I-T-E CIRCUIT BREAKER.
Double Pole, Double Coil.

In dealing with the protection of multiphase power circuits, one of the first points likely to be raised is the heavy current incident upon the starting of most of the types of induction motors now in use. In the case of generator and feeder protection this is a matter of small moment, as when a number of motors are connected to the same feeder, there is slight probability of all or many of them being started at the same instant. The maximum demand upon the generator or feeder is not likely to seriously exceed the normal running load, except upon the occurrence of abnormal condi-

ILLUSTRATION No. 40.
I-T-E LAMINATED.
Triple Pole, Double Coil.

tions, and an adjustment somewhat in excess of the full load current provides ample margin for ordinary working conditions, this case being quite analogous to that of street railway feeders.

The protection by means of circuit breakers of the multiphase motor offers a somewhat different problem, which, on account of its difficulties, has led some engineers to display a preference for fuses for this purpose. The fuse in this connection adds one failing to the already long list for which it stands sponsor; for in case of the blowing of only one fuse of a set supposedly protecting a motor, the motor would gradually slow down, and, coming to a standstill (being still in connection with the remaining wires of the system), would soon burn out unless the current were speedily interrupted by the blowing of one of the remaining fuses, an event somewhat remote from probability, as the current in this case is not necessarily greater than that which the fuses must carry at starting.

The I-T-E Circuit Breaker may, however, be

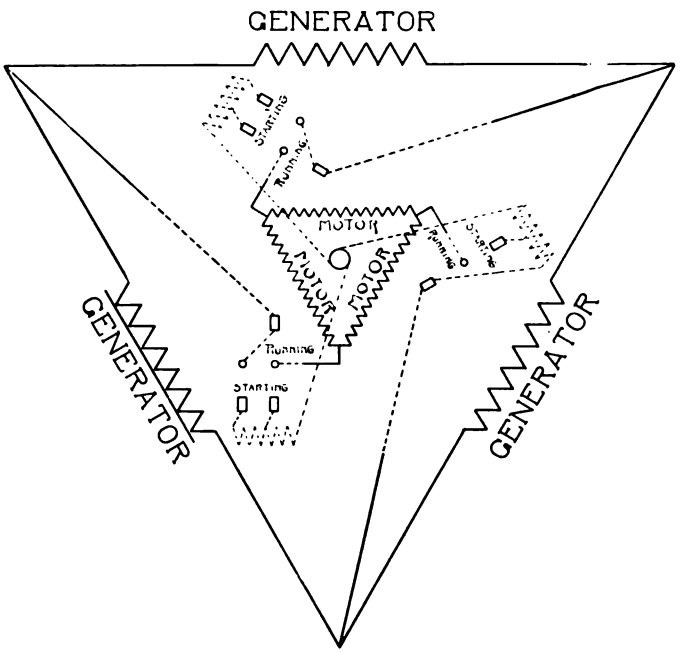


DIAGRAM No. 41.

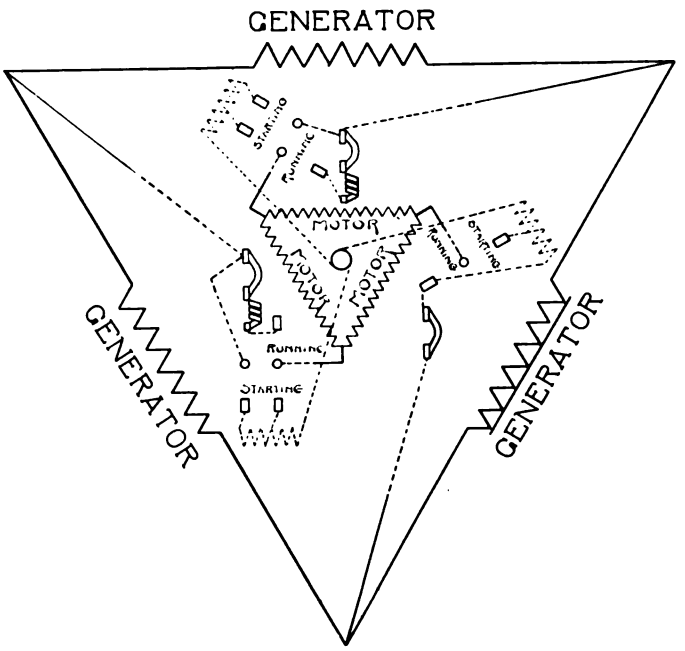


DIAGRAM No. 42.

connected into the polyphase motor circuit ir such a manner that it will be out of circuit during the passage of the excessive starting currents, coming into service only when the motor is connected to line in the running position. Diagram No. 41 shows the usual connections of a three-phase motor and starting device. Diagram No. 42 shows how the three-pole circuit breaker may be introduced so that it is in circuit under running conditions only, being out of circuit at starting. As the switches of this instrument are rigidly connected, they, of necessity, operate in unison and preclude the disastrous possibilities incident upon the use of independent fuses.

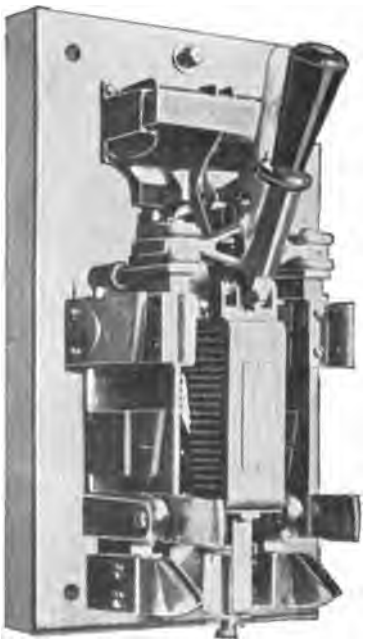
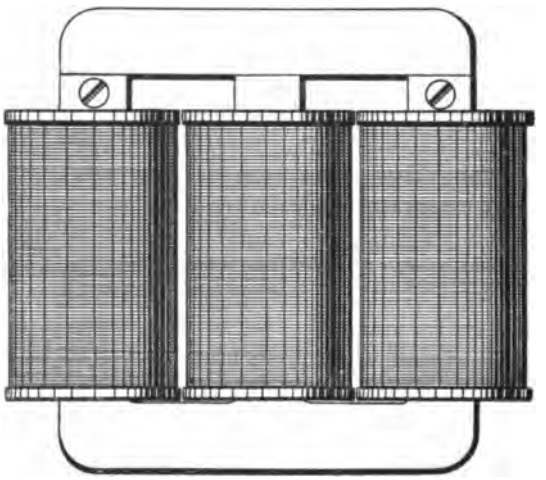


ILLUSTRATION No. 43.

Regarding the types of motors having an internal resistance which is cut out as the motors come up to speed, little need be said, as for this apparatus the standard types of overload instruments afford ideal protection without the need of special connections, because with this type of motor the starting current seldom exceeds full load current by more than 50 per cent., a condition which permits of providing the Circuit Breaker with an adjustment which will allow the passage of the starting current, and yet

give adequate protection to the motor under running conditions. Illustration No. 43 shows an "Overload and No Voltage" I-T-E Circuit Breaker for polyphase work. Not only does it operate upon overload, but it opens the circuit upon a failure of the voltage in either phase of the polyphase system. The instrument shown was designed for a two-phase system; the principles which it involves are applied, however, with equal effectiveness to three-phase systems.



MAGNET USED FOR
I-T-E CIRCUIT BREAKERS
FOR ALTERNATING CURRENT WITH "NO VOLTAGE" RELEASE

REVERSAL TYPE I-T-E CIRCUIT BREAKERS.

The interest aroused by our presentation of REVERSE CURRENT CIRCUIT BREAKERS, in the first number of "Circuit Breaker Practice," seems to demand a further exposition of this subject. As before stated, the function of these instruments is to prevent an undue flow of current in the reverse direction in the circuits of generators operating together in parallel, and in systems employing storage batteries or motor generating sets. In the first-named instance, no matter how reliable the prime movers operating the generators, unexpected variations in the speed of the different units are almost certain to arise, in which event the generators running at the higher speeds bear an undue proportion of the load, and at the same time may be called upon also to furnish current to operate the more slowly moving generators as motors. Where the power is supplied by turbines or steam engines, no argument is needed to prove the probability of such improper operation, while in the latest practice (which represents perhaps the highest development of electrical engineering), employing generators in parallel, operated by synchronous motors, which in turn are connected in parallel, Reverse Current Circuit Breakers are now being employed as a necessary safeguard.

Reverse Current Circuit Breakers accommodate themselves admirably to the protection of storage battery charging sets, their action absolutely preventing a reversal of the battery current into the generator, from which it is supposedly being charged, and these instruments have this feature of especial value, that they may be closed if the circuit is up to, or nearly up to, normal working potential, even though the main switch be open. This permits the employment of the usual practice of first closing the circuit breaker and finally closing

the circuit by means of the hand switch, thus leaving the circuit breaker entirely free to act.

The first REVERSE CURRENT instruments used commercially were designed and made by THE CUTTER COMPANY a number of years ago, in order to meet some peculiar conditions incident upon the use of storage batteries forming a part of the equipment of electric locomotives used in mine work. These locomotives during a part of their run were in connection with the generating station by means of a trolley, but the power for running through low galleries, where overhead wires could not be installed, had to be supplied by other means; accordingly, each locomotive carried a storage battery in parallel with its motors. The batteries took their charge while in connection with the trolley and operated the motors upon the sections where there was no direct connection with the power station. As the line voltage was subject to wide fluctuations, on account of heavy variations in the load, it was necessary to provide means for the disconnection of the battery in case the voltage of the line should fall below that of the battery, causing it to discharge uselessly back into the line. This end was accomplished by the employment of an I-T-E CIRCUIT BREAKER, having a compound-wound operating coil. The instrument is illustrated in cut No. 30, the coil referred to being shown on the right-hand side

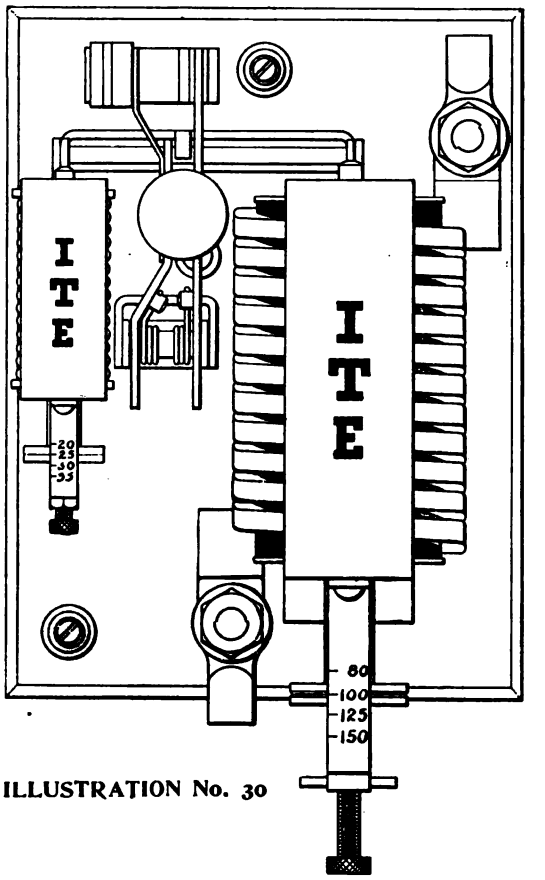


ILLUSTRATION No. 30

of the illustration. The shunt winding of this coil was connected to the terminals of the battery, receiving its full pressure, and was of sufficient power to operate the circuit breaker at the highest voltage to which the battery might with safety be subjected; the series winding of the coil was in the trolley circuit, and connected in such a way that when the current was flowing through it into the battery it was magnetically in opposition to the shunt coil; but upon a discharge of the battery current into the line, this coil would act in conjunction with the shunt coil, thus effecting the operation of the instrument and disconnecting the battery. The small coil to the left and in series with the switch serves to disconnect the battery in case of overload. Cut No. 31 shows the connections of this little instrument, the pioneer circuit breaker of the REVERSAL type.

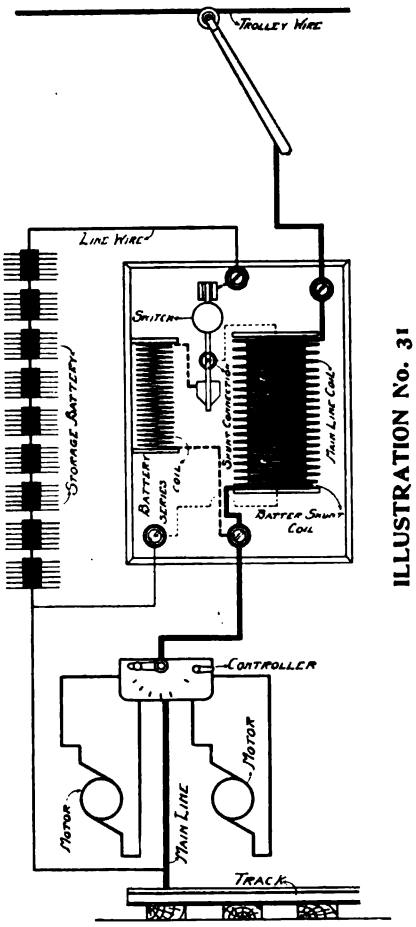


ILLUSTRATION No. 31

Instruments having the reversal feature are made either with or without overload actuation, as may be required, of Standard Switchboard type, having knife blade contacts, or of the Laminated type, in which the switch contact is made by means of a movable member, built of flexible copper leaves, engaging under pressure with flat contact terminals. While the construction of these two types differs somewhat in detail, the principles underlying the operation of each are the same. In the Knife Blade or Standard Switchboard type of instrument the

magnet controlling the operation upon reverse current is placed just above the switch. It consists of two coils—one in series with the switch carrying the main current, and a second of high resistance, which is connected in shunt across the circuit receiving its full voltage. The connection of one end of this coil is made on the movable switch member of the instrument by means of a small spring-actuated plunger, so situated and proportioned that the circuit of the shunt coil is broken before the main circuit is interrupted. By this precaution the coil is protected from the induced electro-motive force liable to occur in the event of the circuit breaker being opened when the circuit is loaded. This precaution is particularly necessary where the instrument combines the overload actuation with the reverse current feature. The connections of these coils will be readily seen by reference to the diagram as shown above, No. 32. The main coil and shunt coil act on one magnetic circuit, which is completed through a movable armature brought into contact with the magnet pole pieces by the act of closing the circuit breaker. This armature is pivoted upon the same centre as that which supports the restraining latch of the instrument, and is actuated by a spring

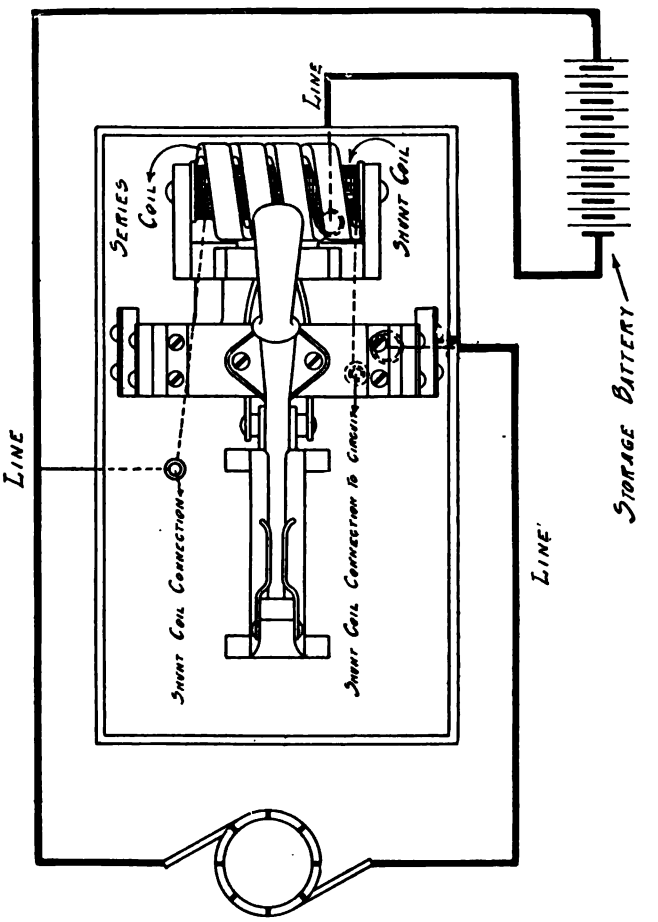


ILLUSTRATION No. 32

tending to draw it away from the pole faces when the magnetism decreases sufficiently to allow its release; it is then projected by the spring against the latch, causing the opening of the circuit breaker.

The shunt coil is so designed as to provide magnetism sufficient to restrain the armature at full potential, even though no current be flowing in the main circuit. It is obvious then that current flowing in one direction in the main coil will act to increase the magnetism induced by the shunt coil, while the flow of current in the opposite direction will decrease this magnetism, or, if the reverse current be of sufficient value, it will overcome the magnetism of the shunt coil and set up a magnetic flow in the opposite direction. In view of this latter phenomenon, it might be urged that the current may be reversed with sufficient rapidity to interfere with the operation of the circuit breaker. Careful tests, however, invariably produce results contrary to this theory, which, it will be seen upon careful consideration of the facts, is hardly tenable. The reversal magnet requires, let us assume, about 80 ampere turns for its proper magnetization, this amount being necessary to enable the magnet to securely grip the armature; owing to the hysteretic qualities of the iron composing the magnetic circuit, the armature will not be released until the resultant magnetizing force is reduced to about 40 ampere turns, but in order to cause the re-engagement of the armature upon the reversed current, the magnetic force must

ILLUSTRATION No. 33

be built up to 80 ampere turns in the contrary direction, and that while the armature and magnet are still in contact.

It must be borne in mind that the attraction of the magnet for its armature rapidly diminishes as they separate. The armature, being of comparatively small mass, moves quite rapidly under the impulse of the controlling spring, and careful calculations show that in our Standard type of Reversal Circuit Breakers—say, for example, of 600 amperes capacity—the current must change in value upon reversal at a rate much in excess of 800 amperes in 1-100 of a second in order to cause faulty action of the instrument. The impossibility of "beating" the instrument by extremely rapid reversal of the current has been proved in a more practical way by carefully arranged tests. Theory and practice unite to prove the reliability of the instrument under all practical conditions.

ILLUSTRATION No. 34

Illustration No. 33 shows an "Overload and Reversal" Circuit Breaker of the Laminated type. In this instrument both the overload and the series reversal coil are placed below the switch, and instead of being in series each with the other, the two are in parallel, each carrying one-half of the total current.

The Reversal Circuit Breakers above described will operate upon a CESSATION OF THE VOLTAGE of the circuit of which they form a part, as in this case the magnetism of the reversal magnet fails entirely. In the majority of cases this feature adds to the value of the instrument, preventing the possibility of a generator not up to potential being thrown, by the injudicious handling of a switch, on to an active circuit. Cases may arise, however, where it is desired that the instrument, while operat-

ing upon reversal, shall be capable of remaining closed when the line is idle. To meet this condition the Circuit Breaker shown in illustration No. 34 has been brought out. It has, in addition to the usual switch and controlling mechanism, an operating coil of comparatively high resistance, but normally open-circuited. Upon a reversal of the current a polarized relay connected in series with the Circuit Breaker brings this coil into circuit across the mains, causing the instant operation of the instrument. In the device shown in the cut an overload coil is also provided.

The wide experience which The Cutter Company has had in the design of special apparatus, and the amount of research which they have brought to bear upon the development and perfecting of REVERSAL types are such as to place them in a position to understand most fully and to meet most satisfactorily the growing demand for this class of instruments.

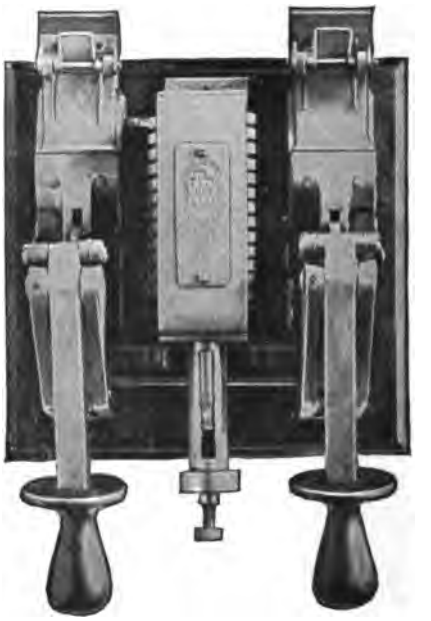


ILLUSTRATION No. 35.

"I-T-E LAMINATED" SPECIAL DOUBLE POLE TYPE INDEPENDENTLY OPERATING ARMS

I-T-E CIRCUIT BREAKER LUGS.

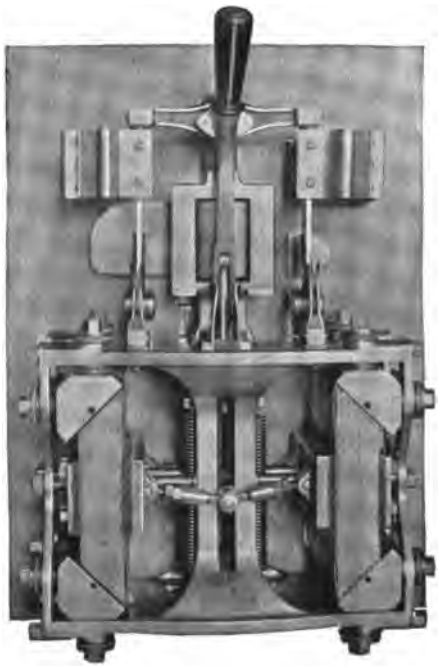
Where cables rather than bars are used in connecting up circuit breakers, the question of lugs becomes one of some importance. The illustration shows an approved form of lug and indicates its various dimensions.

Lugs are considered strictly a circuit breaker accessory and are not included in the price of "back connection" instruments. They are, however, supplied with "face connection" instruments where the cost of the lug is offset by the saving in the copper studs.

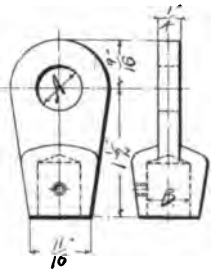
Lugs form a quick and inexpensive method of connection, and while not frequently used on switchboards, are very commonly employed in large industrial plants.

Prices for Pure Copper Lugs (see illustration No. 10), according to size, 50 cents, 65 cents, $1.50, $4.50, $5.00 each lug, less usual discounts.

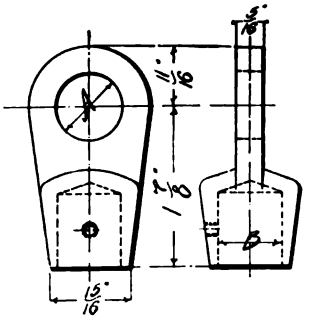
Instruments of this type and size are in operation in the Public Printing Office, Washington, D. C., and in the plants of The Western Electric Company, both New York and Chicago.



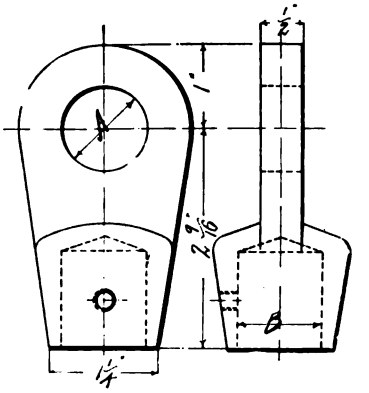
4000-AMPERE DOUBLE POLE I-T-E CIRCUIT BREAKER



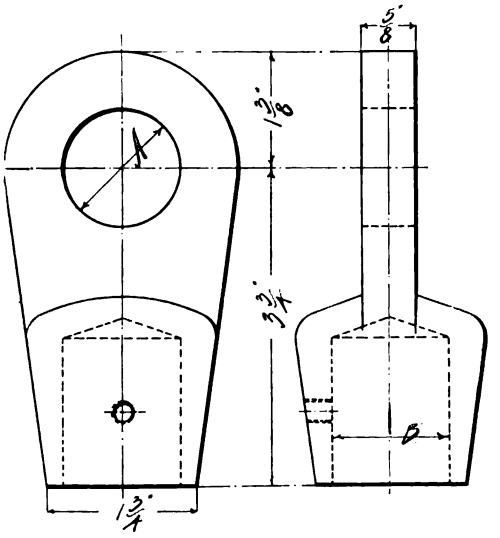
CODE WORD	A	B
LUGIDST	13/32	SOLID
LUGIPEE	11/32	5/16
LUGIP	11/32	3/16
LUGIRE	13/32	1/4
LUGIT	13/32	9/16
LUGIAIR	11/32	3/8
LUGIMT	17/32	SOLID
LUGIST	17/32	7/16
LUGIGHT	17/32	1/2



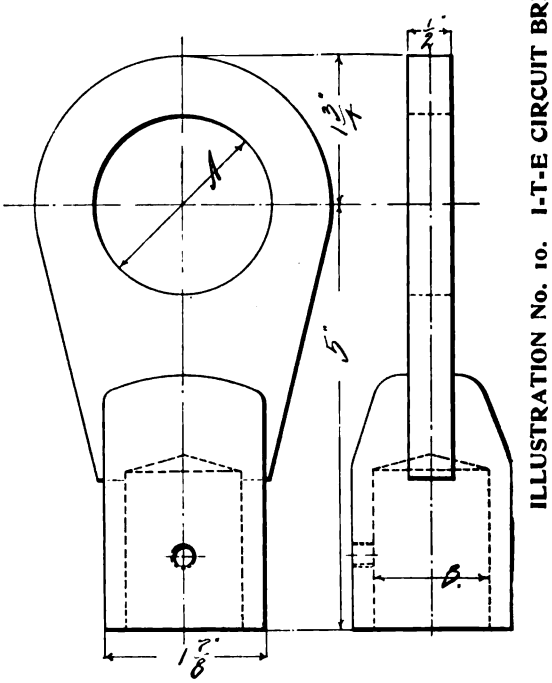
CODE WORD	A	B
LUGYDSYN	5/32	SOLID
LUGYTOTEM	5/32	3/16
LUGYGERIT	5/32	1/4
LUGYPTOM	5/32	SOLID
LUGYDMOK	5/32	1/4
LUGYRRIP	5/32	3/8
LUGYPUT	5/32	SOLID
LUGYCANT	5/32	3/8
LUGYBIT	5/32	3/16



CODE WORD	A	B
LUGAET	5/32	SOLID
LUGADP	5/32	3/16
LUGADP	5/32	1/4
LUGARG	1 3/32	SOLID
LUGAAE	1 1/32	1/4
LUGAITE	1 1/32	1"
LUGAUGH	1 1/32	1 1/16



CODE WORD	A	B
LUGOPEA	1 5/32	SOLID
LUGOTRUD	1 5/32	1"
LUGOPHEAR	1 5/32	1 1/16
LUGOCOUND	1 5/32	SOLID
LUGOROST	1 5/32	1 1/16
LUGOGREY	1 5/32	1 1/4
LUGOME	1 5/32	SOLID
LUGOPINE	1 5/32	1"
LUGODIMY	1 5/32	1 1/16



CODE WORD	A	B
LUGENT	1 17/32	SOLID
LUGEITER	1 5/32	1 1/4
LUGERTH	1 17/32	1 1/16
LUGEYEST	1 5/32	SOLID
LUGETROCH	1 5/32	1 1/4
LUGETOUR	1 5/32	1 1/16
LUGEXTUP	1 5/32	SOLID
LUGECE	1 5/32	1 1/16
LUGEPORT	1 5/32	1 1/4
LUGERIP	1 5/32	1 1/16
LUGEMY	2 5/32	SOLID
LUGEZ	2 5/32	1 1/4
LUGEZIC	2 5/32	1 1/16

ILLUSTRATION No. 10. I-T-E CIRCUIT BREAKER LUGS

I-T-E CIRCUIT BREAKERS
FOR THE PROTECTION OF CAR EQUIPMENT.

The problem which confronts the street railway manager is to make his road PAY. He must secure the maximum return from every dollar invested, whether it be spent for equipment or for labor. He cannot afford to have his cars operated by electrical engineers, but he can secure equally good results by the employment of ordinary labor, supplemented by a suitable protective device—the I-T-E Car Circuit Breaker.

The purpose of this instrument is to prevent the motor from being subjected to excessive currents from any cause, whether it be faulty connections, improper handling or an effort to crowd the motor beyond its capacity.

Did you ever consider what a difference safety valves have made in the operation of steam boilers? Think how gingerly a man would go about the running of a boiler at 200 lbs. pressure if there were no safety valve on it; quite likely fears for his own safety would result in such over-caution that the output of the boiler—its usefulness—would be cut in half and constant inspections would be necessary, in the absence of either of which, disaster would follow. Is it not much the same way with the motor equipment of a trolley car? If it is not protected automatically against overloading, constant vigilance must be exercised by the operator lest damage result to the apparatus; but suppose the equipment is provided with an electric safety valve, an I-T-E Circuit Breaker, then it may be worked to its utmost without fear of injury, the operator will be relieved of unnecessary concern and can devote his entire energies to the running of his car, while the circuit breaker takes care of the

apparatus, giving him no trouble so long as he uses it properly, but serving instant notice in case of carelessness. Oftentimes improper handling of apparatus, connections wrongly made, burn-outs or short-circuits in the controller, are discovered only as the result of the damage which they have already caused to the motor; but where the equipment is protected by an I-T-E Circuit Breaker, this instrument calls attention to the difficulty and makes possible its correction before harm has been done. This is one of the cases where an ounce of prevention is worth vastly more than a pound of cure, for not only is the cost of repairs very greatly lessened by the use of the circuit breaker, but a great saving may be effected in the matter of extra armatures and reserve equipments.

In the items of fixed charges as well as operating expenses I-T-E Car Circuit Breakers will save you money.

Almost ten years ago we made the first circuit breaker designed for the protection of trolley cars. Our apparatus met with the strenuous opposition of the big companies, who did not then make a car circuit breaker and who consequently stated that circuit breakers were not a necessity, as we claimed they were; on the contrary, they said they were a nuisance. Feeling that the time was not ripe for our product, we withdrew from this particular field and developed our product along another line. We have, however, for years past devoted practically our entire time to the manufacture of circuit breakers, and our apparatus is admittedly

The circuit breaker is enclosed in a strong hardwood box, which is as small as is consistent with efficiency. Dimensions, 12 inches long, 8⅝ inches wide, 5 inches deep. It is designed to be placed in the hood of the car, over the head of the motorman.

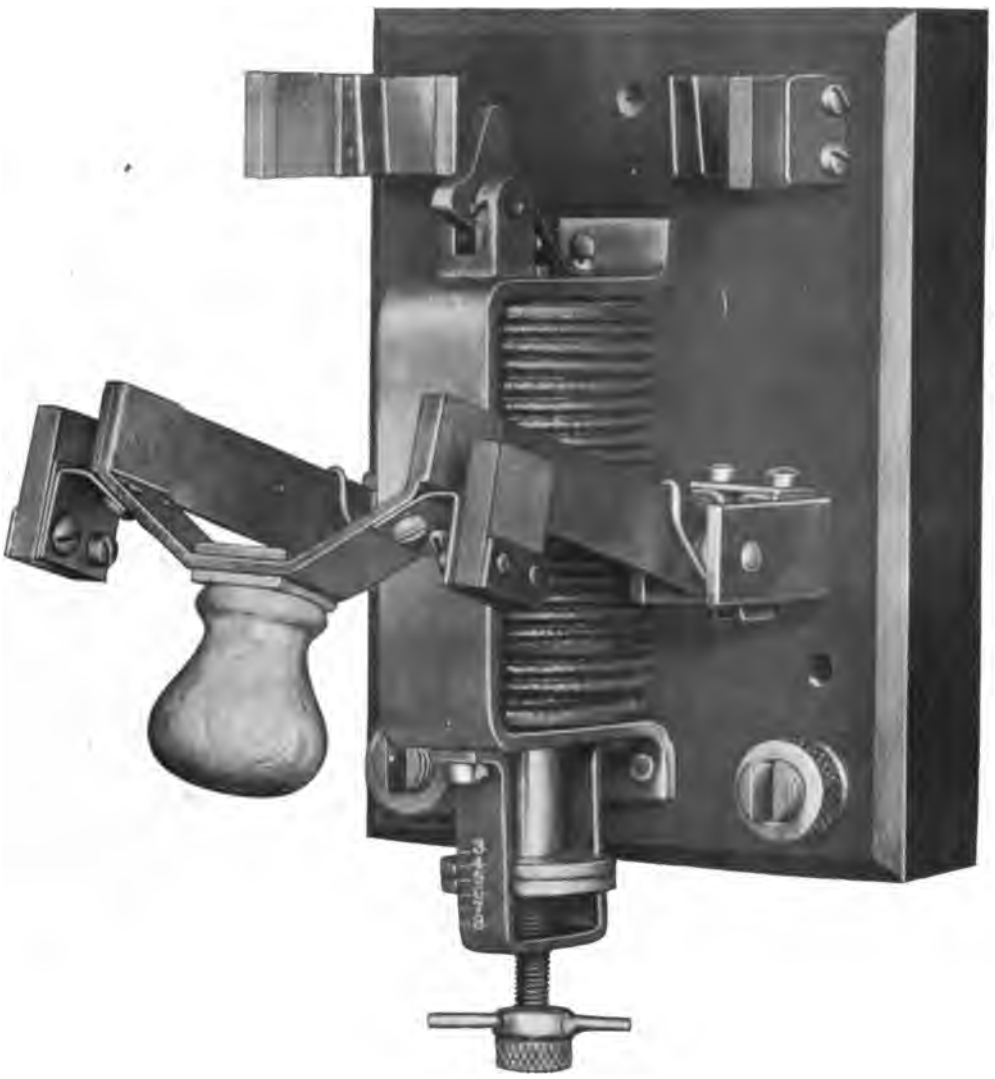
superior to any on the market. Assured that the time would come when the correctness of our position, namely, that circuit breakers were a necessity on trolley cars, would be fully demonstrated, we have worked with the utmost care over this device, also knowing the use to which it would be subjected. In this instance only have we waited for others to do the necessary missionary work, now that the demand is created, we are prepared to take advantage of it and place upon the market a piece of apparatus infinitely superior to anything heretofore obtainable.

THE MARKET IS NOW READY FOR OUR APPARATUS AND OUR APPARATUS IS NOW READY FOR THE MARKET.

I-T-E Circuit Breaker.
For the protection of car equipments, removed from its box.

This device is electrically and mechanically superior to any similar piece of apparatus on the market; it has been designed with a view to making its operation as silent as possible, even in the event of the severest overload, a point of great importance during the "rush" hours, when platforms, both front and back, are apt to be well crowded. The circuit breaker is readily opened by hand and thus dispenses with the usual hood-switch.

Made for various voltages and of any required capacity.



SINGLE POLE OVERLOAD CIRCUIT BREAKER

"I-T-E MIDGET JUNIOR" TYPE

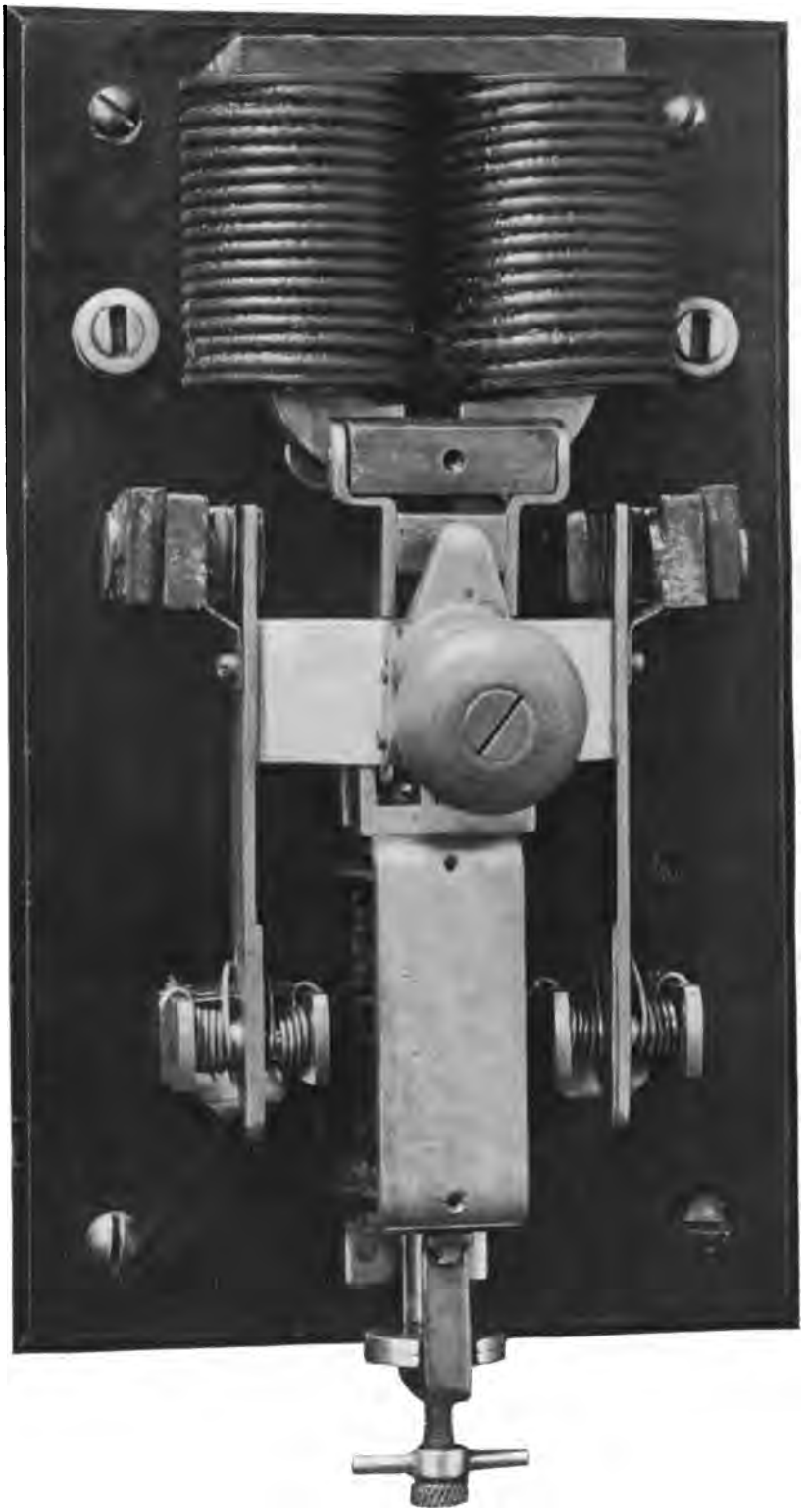
A small instrument for small work. For the protection of small motors and lighting circuits.

Capacities up to 24 amperes.

Voltage up to 500.

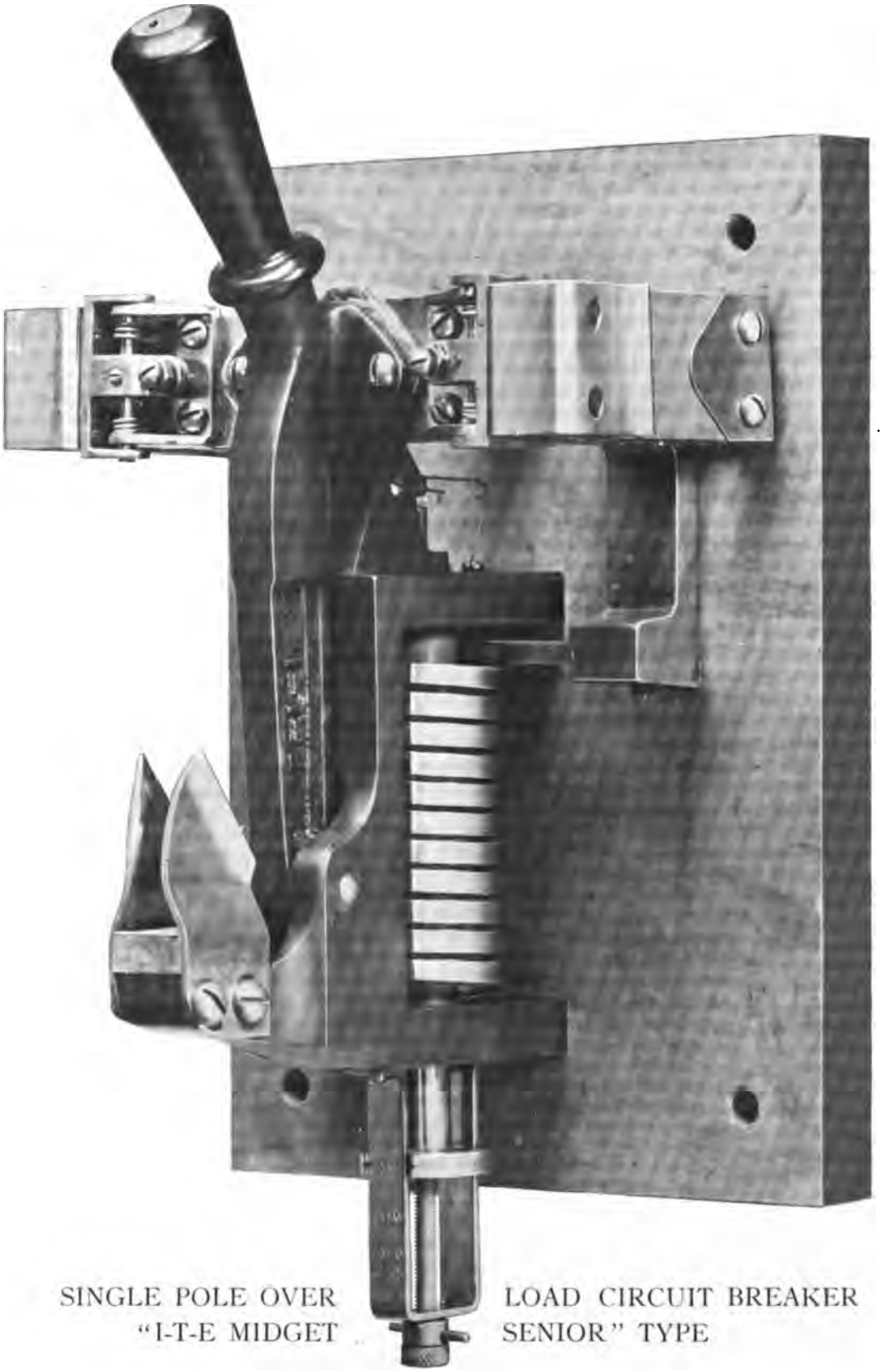
SINGLE POLE OVERLOAD AND NO VOLTAGE CIRCUIT BREAKER
"I-T-E MIDGET JUNIOR" TYPE

An instrument for motor protection, operating upon overload or upon interruption of the current supply. Made of any capacity required.



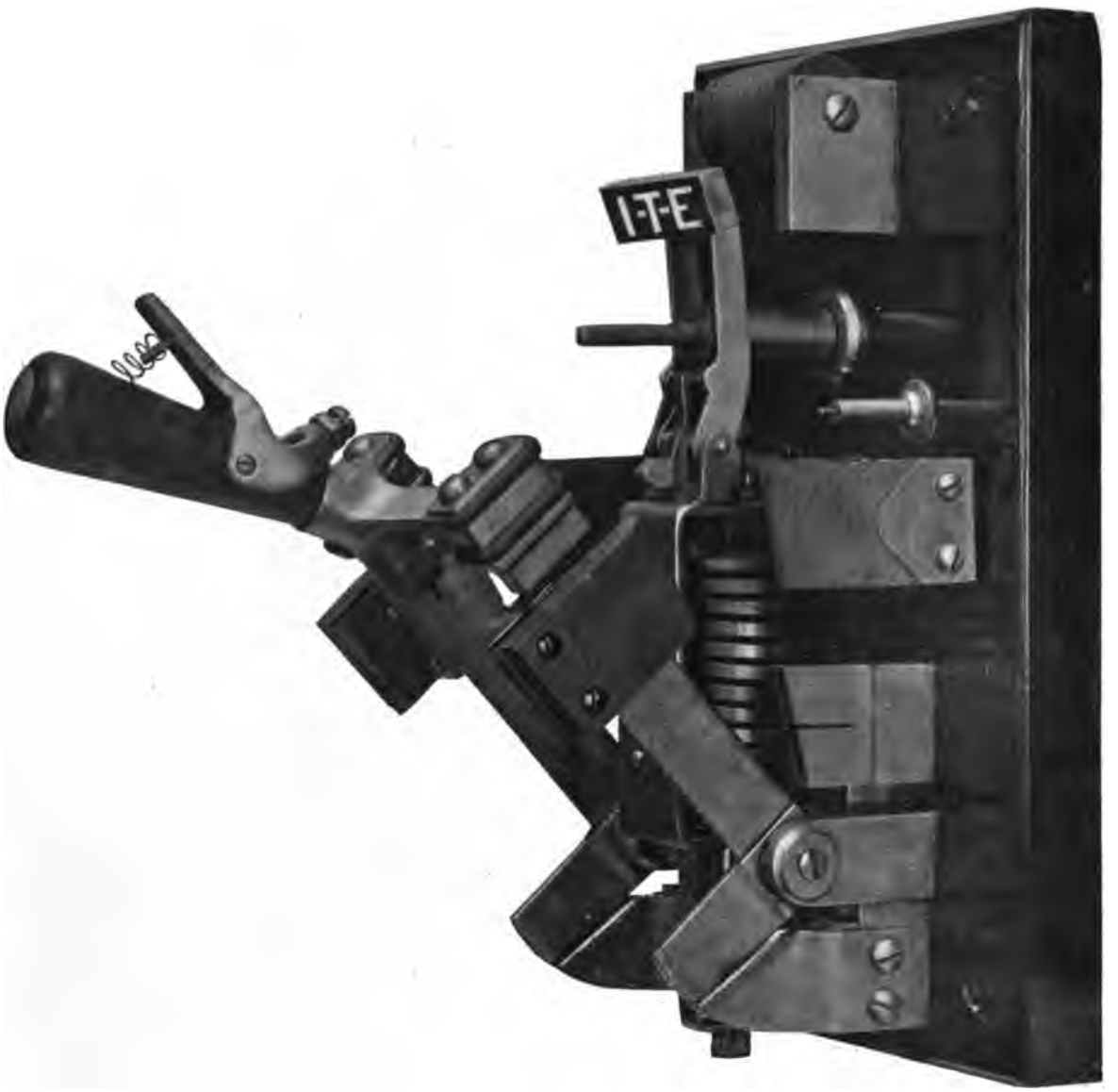
SINGLE POLE OVERLOAD AND UNDERLOAD CIRCUIT BREAKER
"I-T-E MIDGET JUNIOR" TYPE

It is especially designed for the protection of storage batteries in charging, serving not only to protect them from overload, but also preventing a discharge from the battery back into the line from which it has been charged. Made of any required capacity.



SINGLE POLE OVER LOAD CIRCUIT BREAKER
"I-T-E MIDGET SENIOR" TYPE

It is well adapted to the protection of small generators, feeders or motors. It is in the latter field that it has attained its greatest popularity. Its simple design and substantial construction particularly recommend it for use in connection with the electrical equipments of factories, machine shops and foundries. Capacities up to 300 amperes. Voltage up to 600.



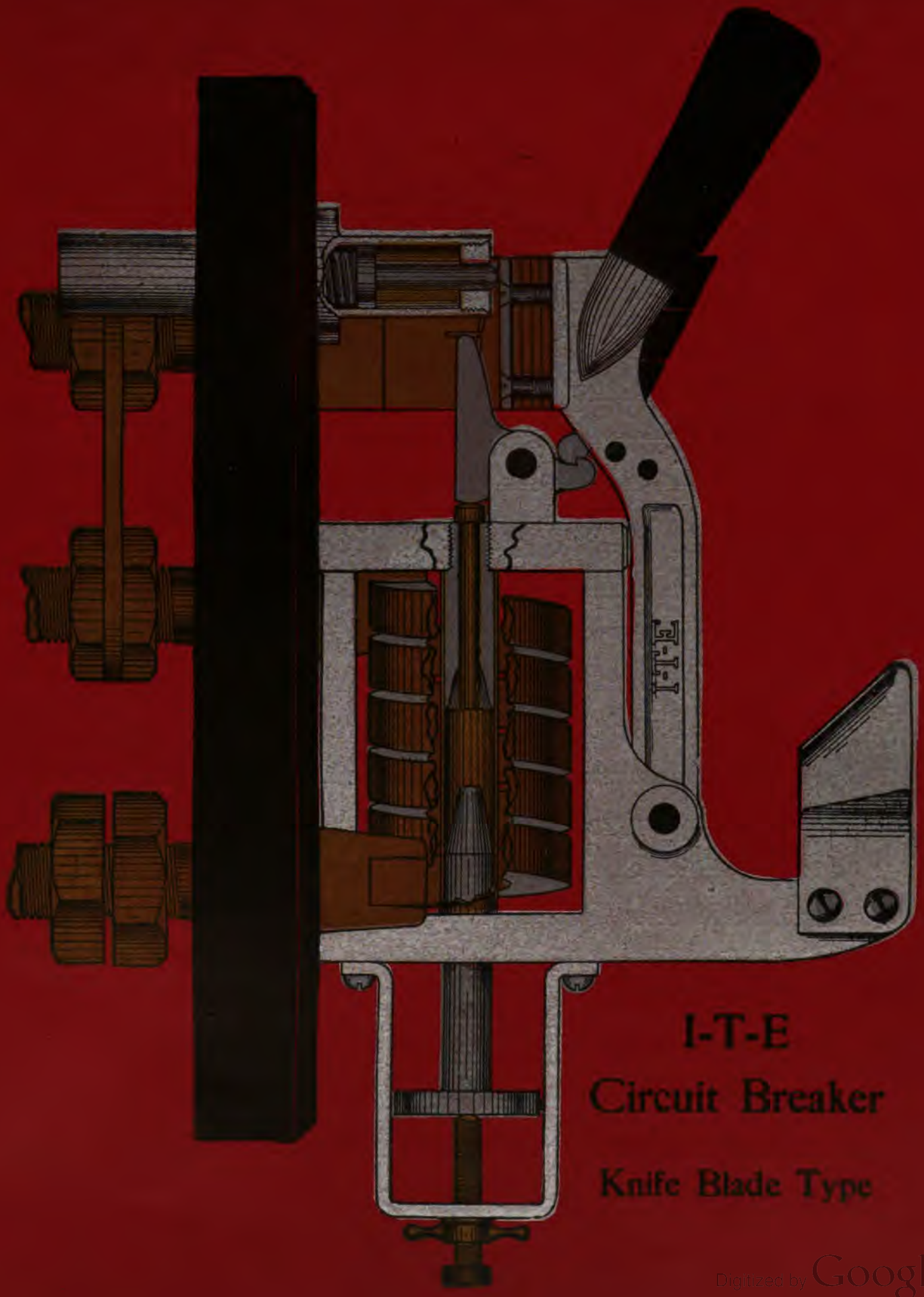
DOUBLE POLE OVERLOAD AND NO VOLTAGE CIRCUIT BREAKER

"I-T-E MIDGET SENIOR" TYPE

A Circuit Breaker for the protection of motors from overloads and short-circuits; it also cuts out the motor upon failure of the current supply.

Capacities up to 300 amperes. Voltage, 250 or less.

Other types for larger work.

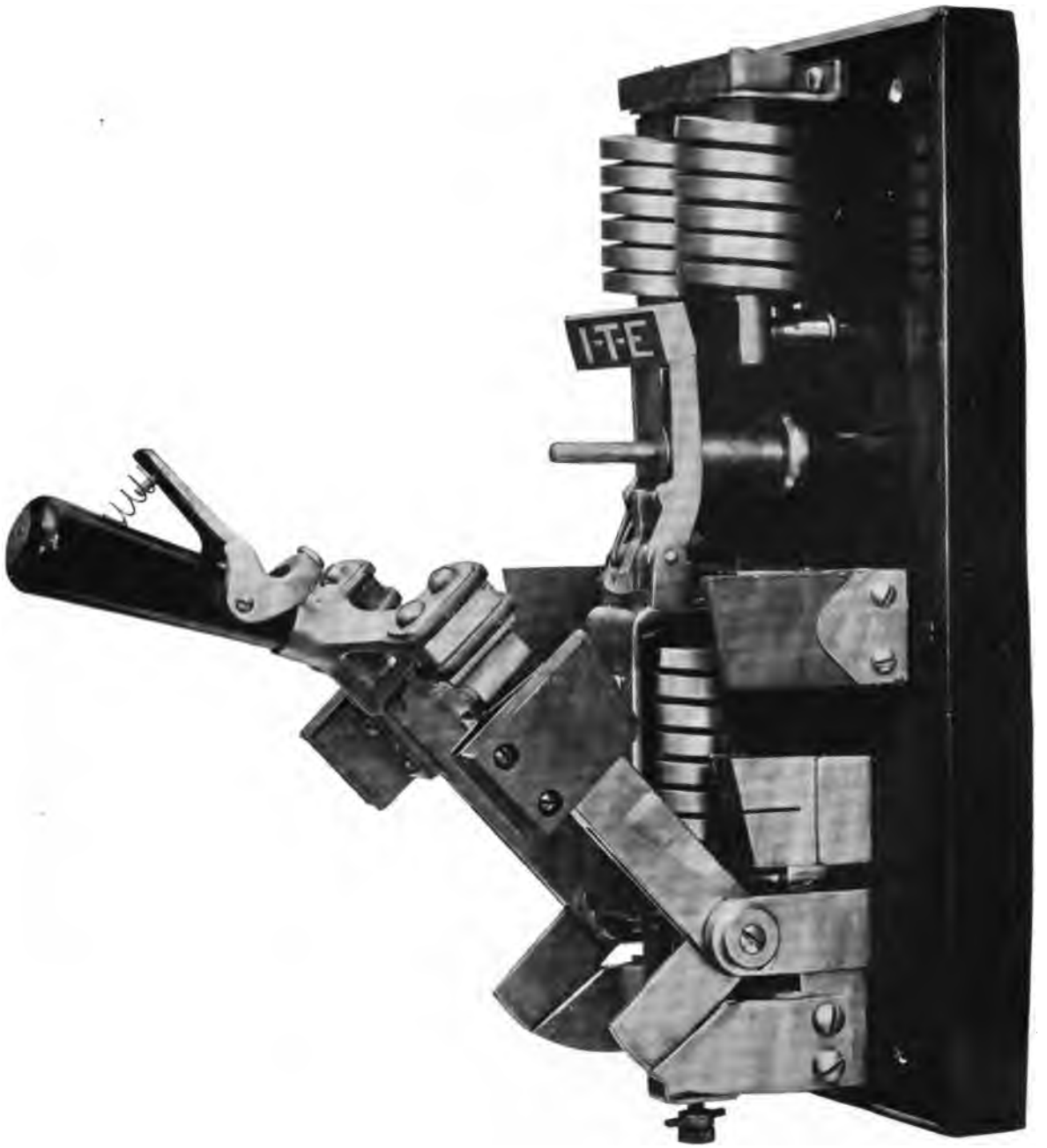


I-T-E
Circuit Breaker

Knife Blade Type

The I-T-E Principle Makes Circuit Breakers Practical

How the "I-T-E" principle is attained will be seen by referring to the other side of this sheet. The plunger is magnetically drawn up with increasing velocity until it strikes the pin, which in turn strikes upon the trigger, thus releasing the catch and forcing open the contacts of the breaker. The greater the amount of current, the more rapid is the movement of the plunger, and the greater the force operating upon the trigger, so that it strikes a hammer-blow, overcoming friction and being further supplemented by the spring. The greater the overload, the greater the necessity for opening the circuit; the greater the necessity for opening the circuit, the quicker it is accomplished. This, in a nutshell, is the "I-T-E" principle, and it is a principle without which circuit breakers are faulty in construction and unsatisfactory in operation.

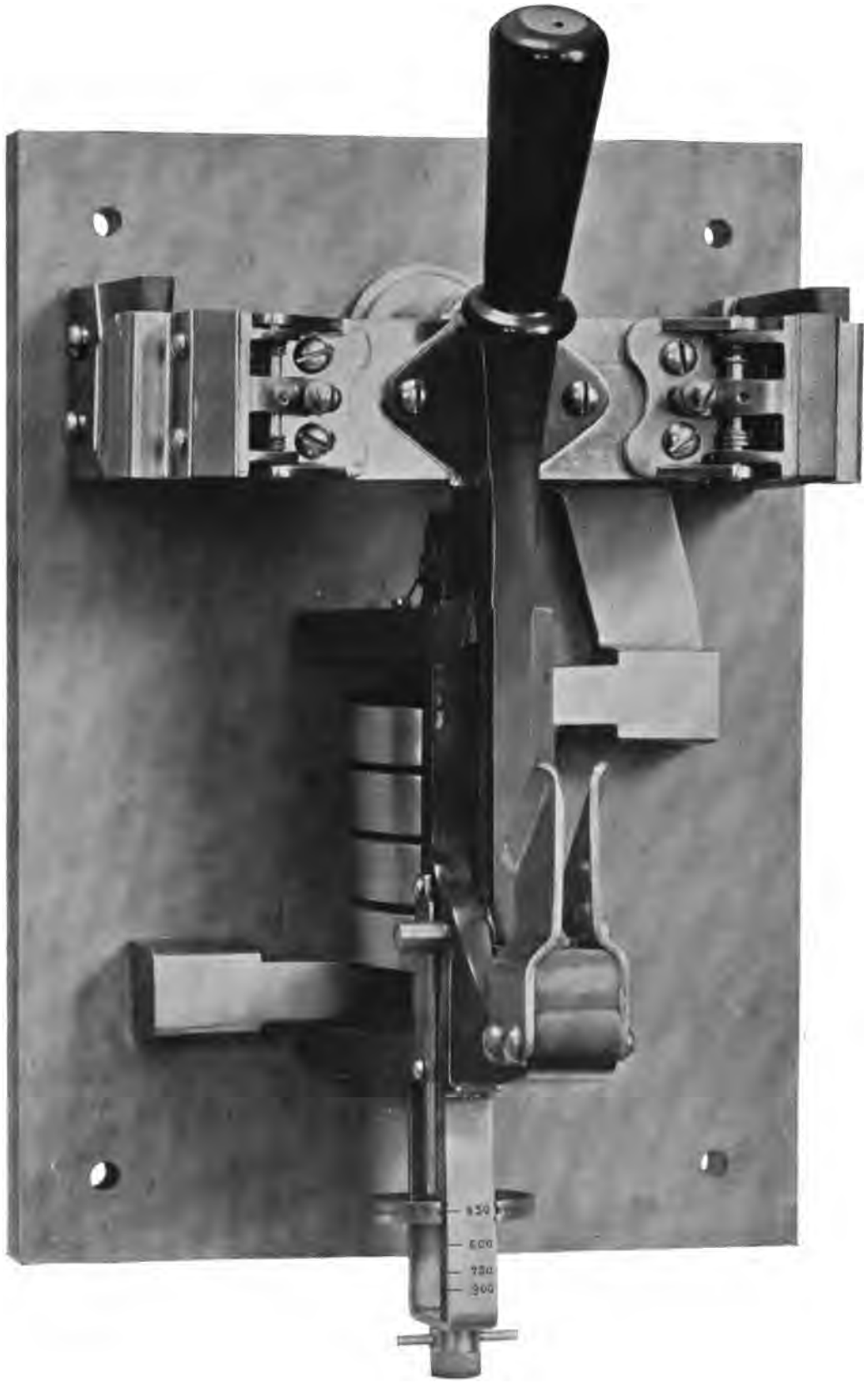


DOUBLE POLE OVERLOAD AND UNDERLOAD CIRCUIT BREAKER
"I-T-E MIDGET SENIOR" TYPE

Connected in the circuit of the storage battery, it protects it from short-circuit and from reversal into the charging generator.

Capacities up to 300 amperes. Voltage up to 250.

Other types are made for larger currents and for higher voltages.

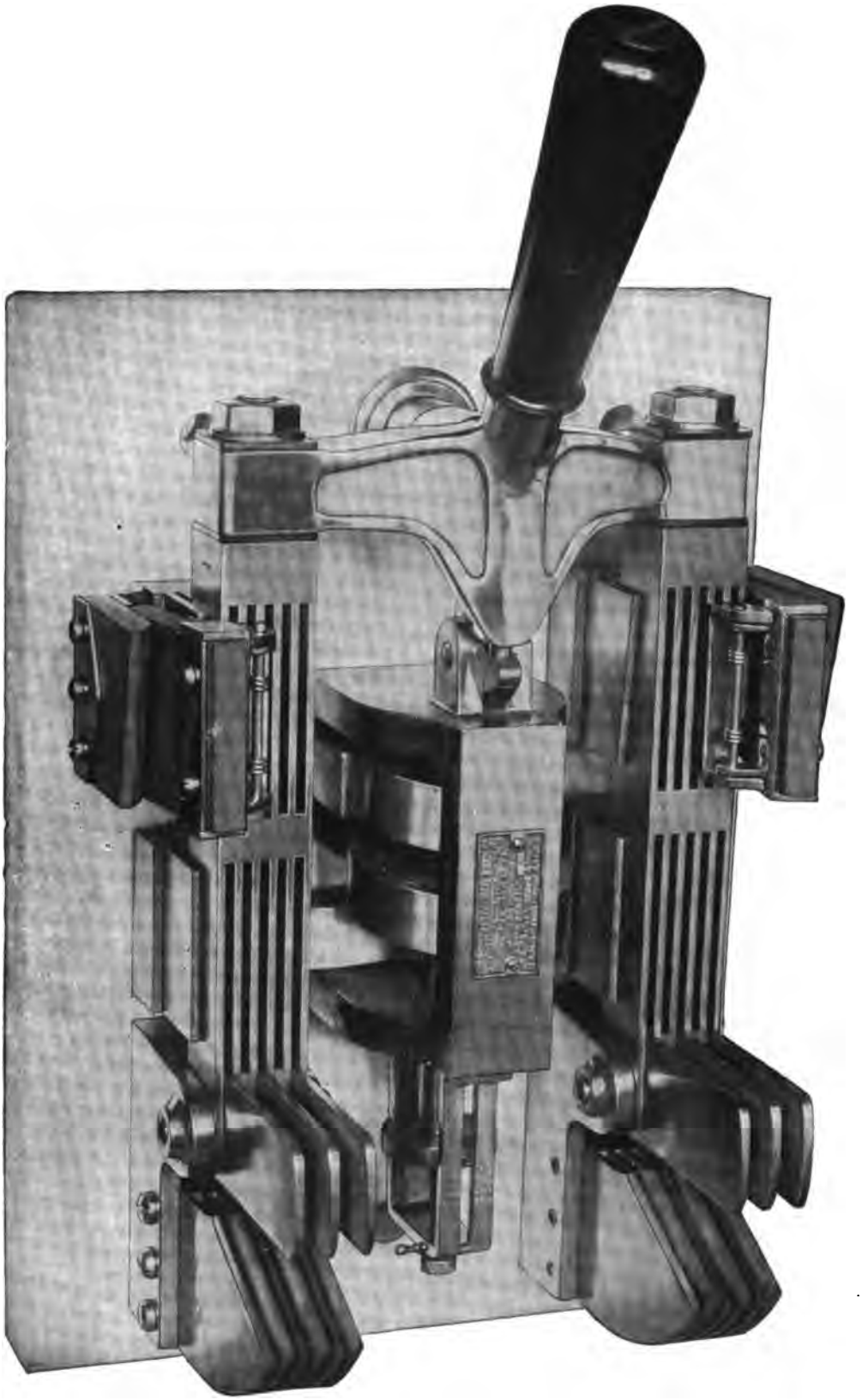


SINGLE POLE I-T-E OVERLOAD CIRCUIT BREAKER
"STANDARD SWITCHBOARD TYPE"

For eight years the standard, both in this country and abroad, for the protection of power and lighting circuits, generators and motors. It has proven a satisfactory instrument under the severe tests incident upon use in street railway power stations.

Capacities up to 1500 amperes.

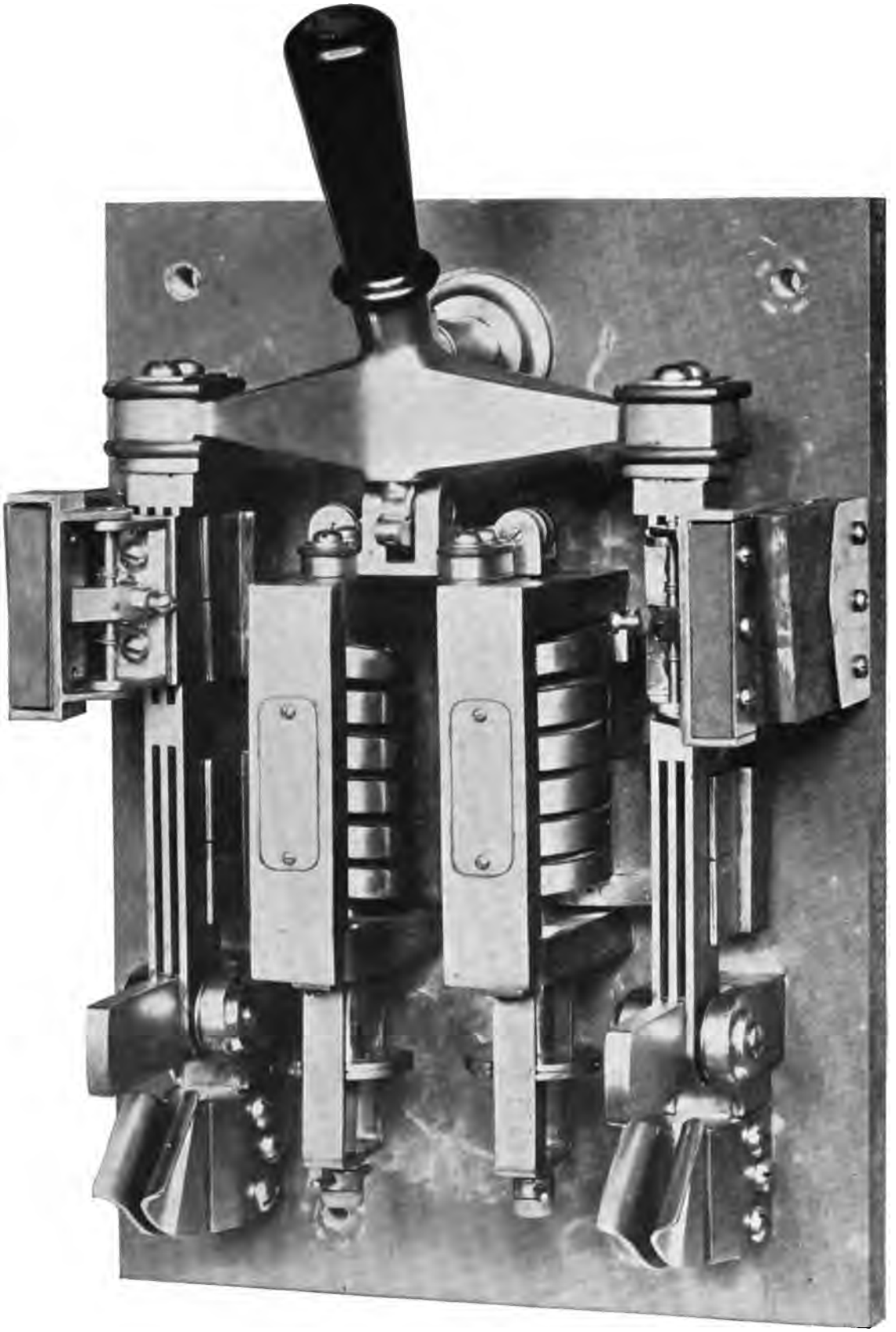
Voltage up to 600, *alternating or direct.*



DOUBLE POLE OVERLOAD CIRCUIT BREAKER
I-T-E "STANDARD SWITCHBOARD TYPE"

A Circuit Breaker for the protection of generators, lighting or power circuits.

Capacities up to 1250 amperes.
Voltage up to 250.
Additional types for heavier work.

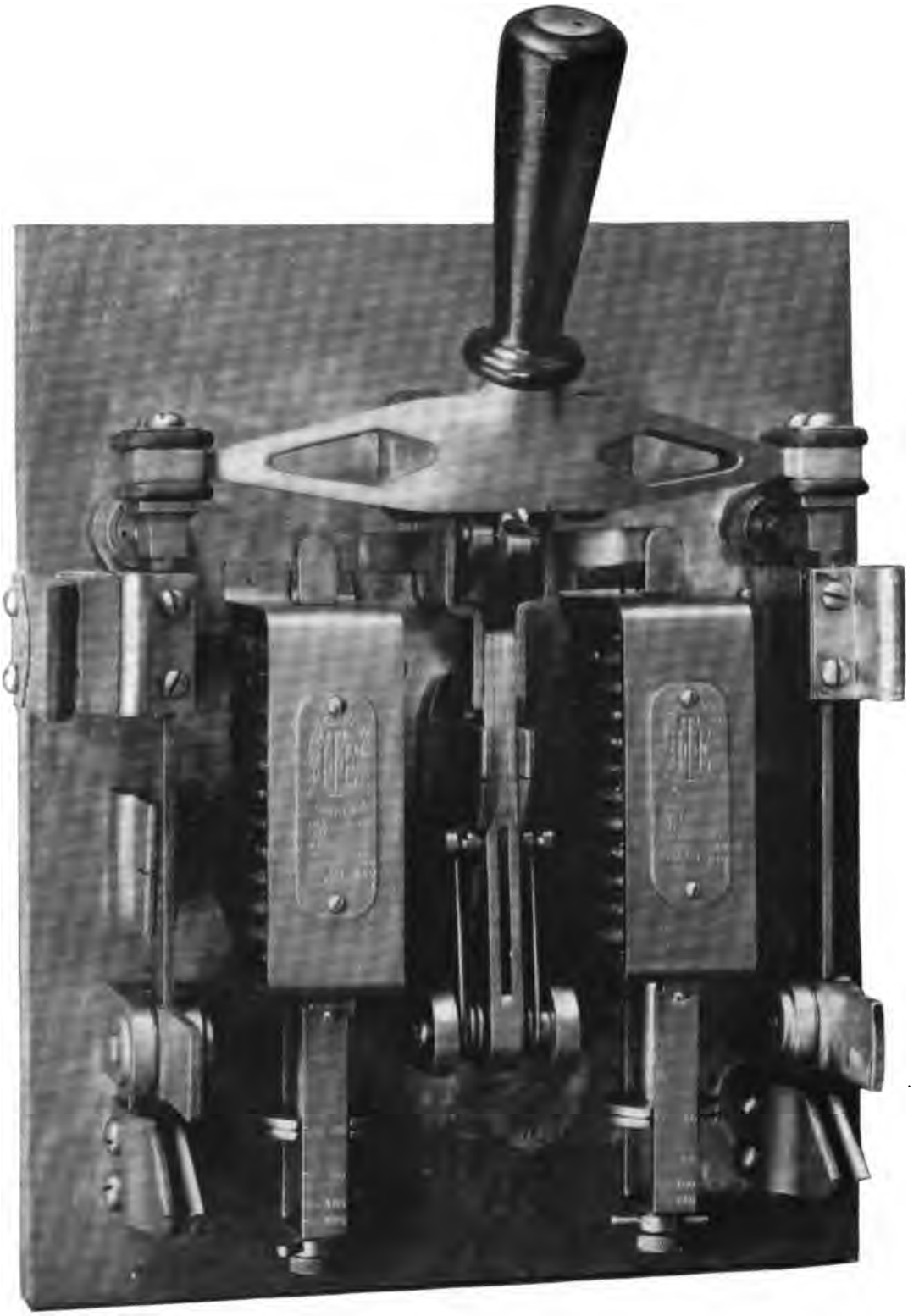


DOUBLE POLE, DOUBLE COIL, OVERLOAD CIRCUIT BREAKER
"I-T-E STANDARD SWITCHBOARD" TYPE

Having two coils, it operates upon the occurrence of overload in either one or both sides of the circuit. Adapted for the protection of three-wire apparatus and circuits, either direct or alternating current, and for two-phase alternating current work.

Capacities up to 600 amperes. Voltage, 250.

Instruments of greater capacities and adapted to higher voltages made in laminated types.



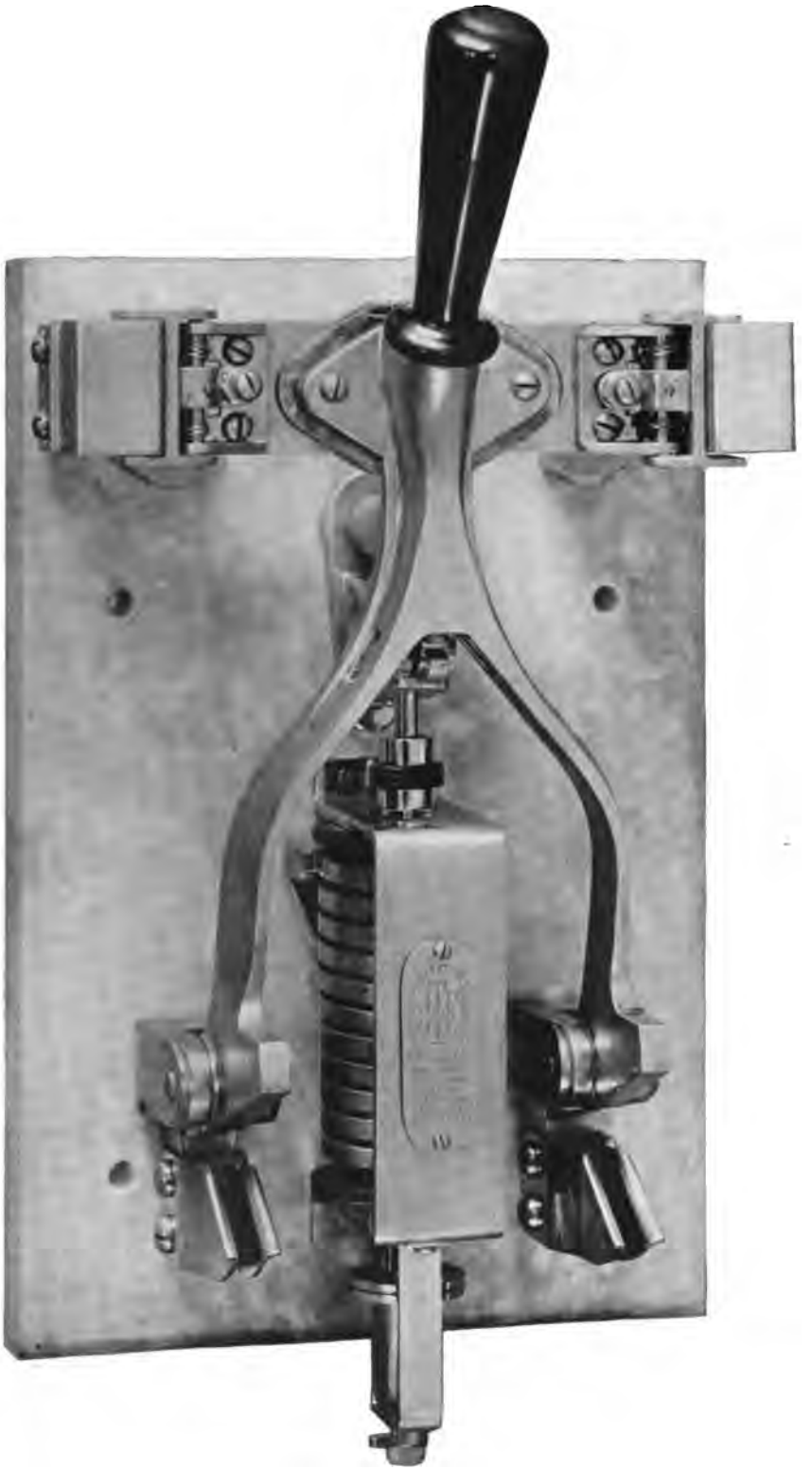
TRIPLE POLE OVERLOAD CIRCUIT BREAKER
"I T-E MIDGET SENIOR"

Having two operating coils, this instrument responds to an overload affecting either or both sides of the circuit. It is especially adapted for the protection of direct current generators operating on the Edison three-wire system, and for use in connection with three-phase alternating current apparatus.

Capacities up to 200 amperes.

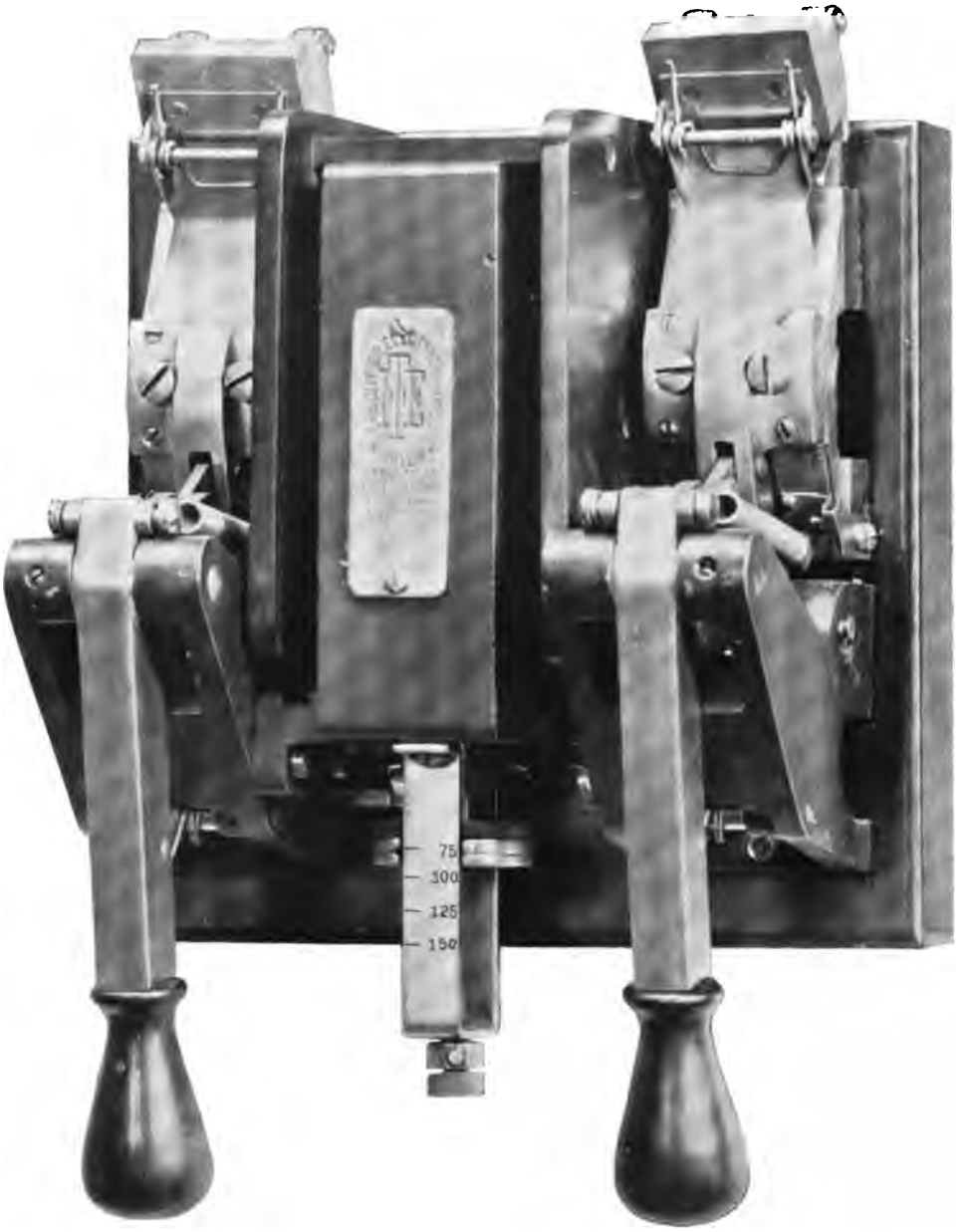
Voltage, 250.

Other types for heavier work.



I-T-E SINGLE POLE OVERLOAD CIRCUIT BREAKER
"ALTERNATING CURRENT TYPE"

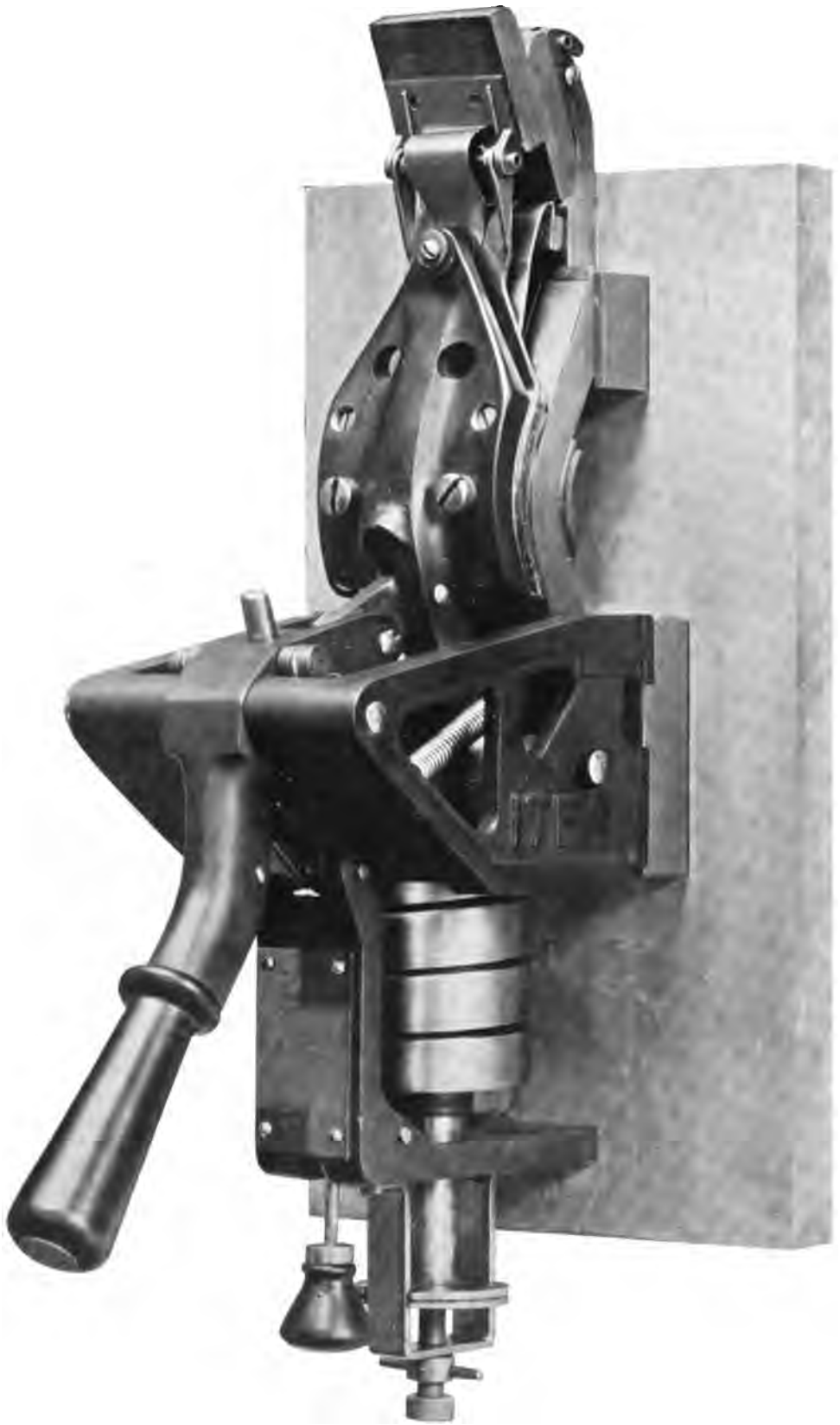
The standard instrument for single-phase alternating current plants.
Capacities up to 200 amperes.
Voltage, 1100 to 2200.
Larger capacities made in laminated types.



DOUBLE POLE OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED" FOR 250 VOLTS OR UNDER

An instrument which combines great effectiveness with small size. Within its range it is an admirable switchboard instrument and is used to good advantage where economy of space is an important item. It is in especial favor, however, for motor protection.

Made in capacities up to 300 amperes. Also made in single pole for 500 volts.



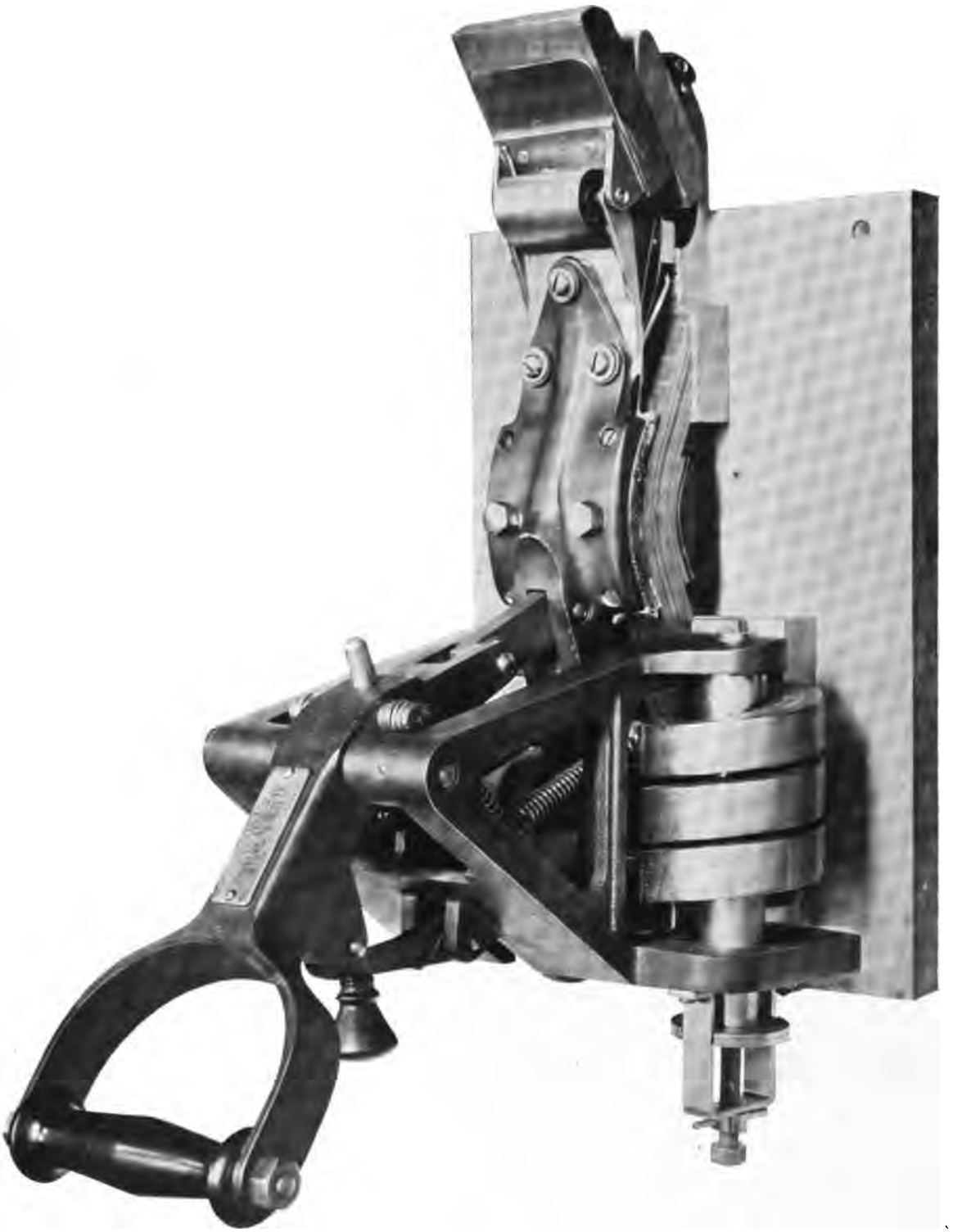
SINGLE POLE OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED," FOR 250 VOLTS

Particularly to be recommended on account of its small size combined with high efficiency.

Its greatest width is but 4¾ inches.

Made in capacities up to 1500 amperes.

For the protection of motors, generators or feeders.



SINGLE POLE OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED," FOR 750 VOLTS OR UNDER

It has no equal for the protection of railway generators and feeders. The highest possible standard.

Capacities up to 1500 amperes.

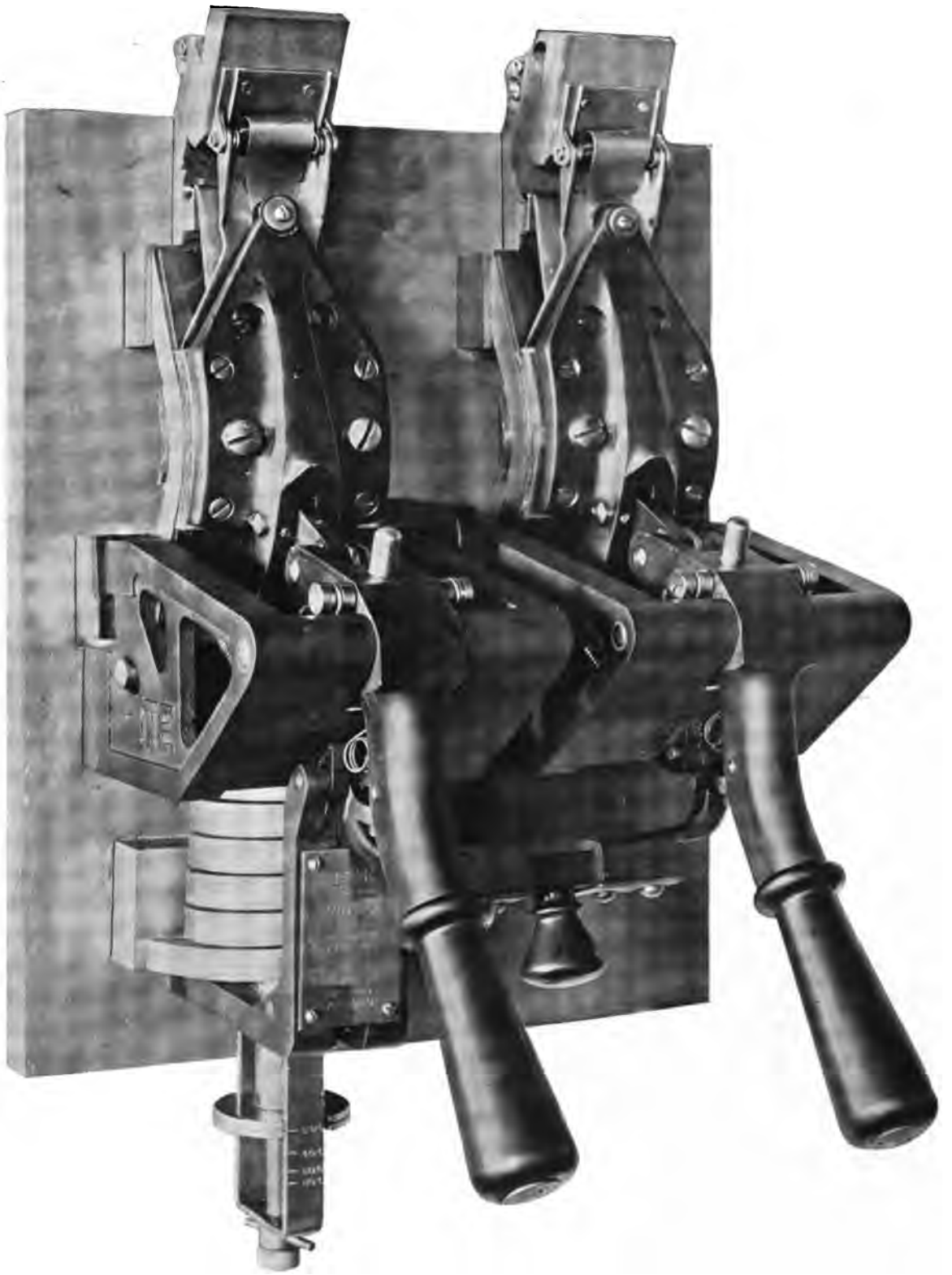
Also made for alternating current, 2200 volts.

OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED"

It is the smallest instrument of its capacity ever made, but it is large enough to meet in the most successful manner the severest conditions of railway work.

For 2000, 2500 and 3000 amperes. We build them up to 7500 amperes, but the design is slightly different. We meet each condition with a design which is *exactly right.*

Voltage up to 750. Direct or alternating.



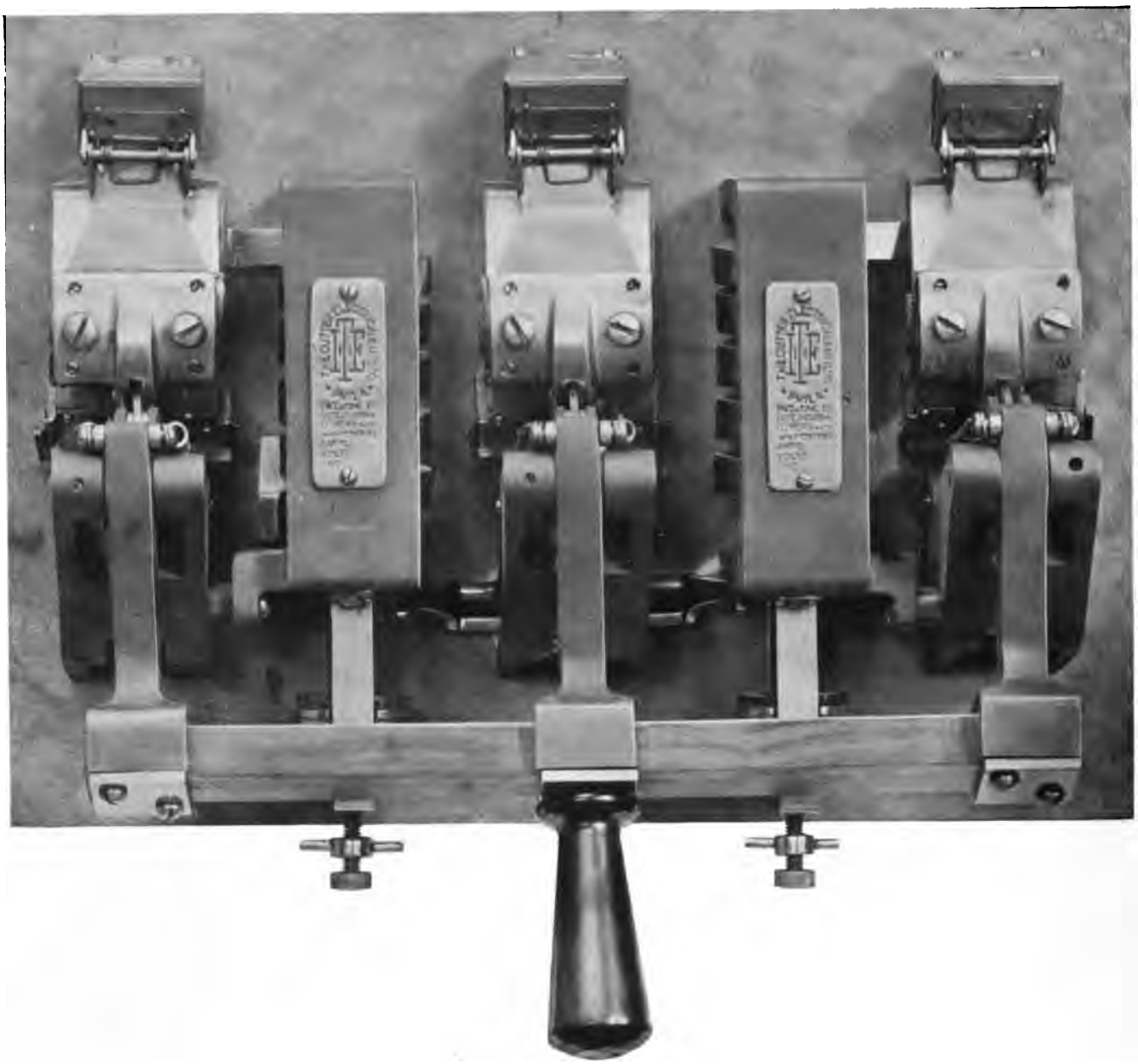
DOUBLE POLE OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED".

The switches may be closed independently. They open together, thus fulfilling the purposes both of circuit breaker and hand switch.

Equally adapted for the protection of generators, feeders or motors. Made also with the poles rigidly connected.

Capacities up to 1500 amperes are illustrated by the cut. This type is also made up to 7500 amperes, according to designs best adapted to these sizes.

Voltages up to 750.



TRIPLE POLE OVERLOAD CIRCUIT BREAKER
"I-T-E LAMINATED"

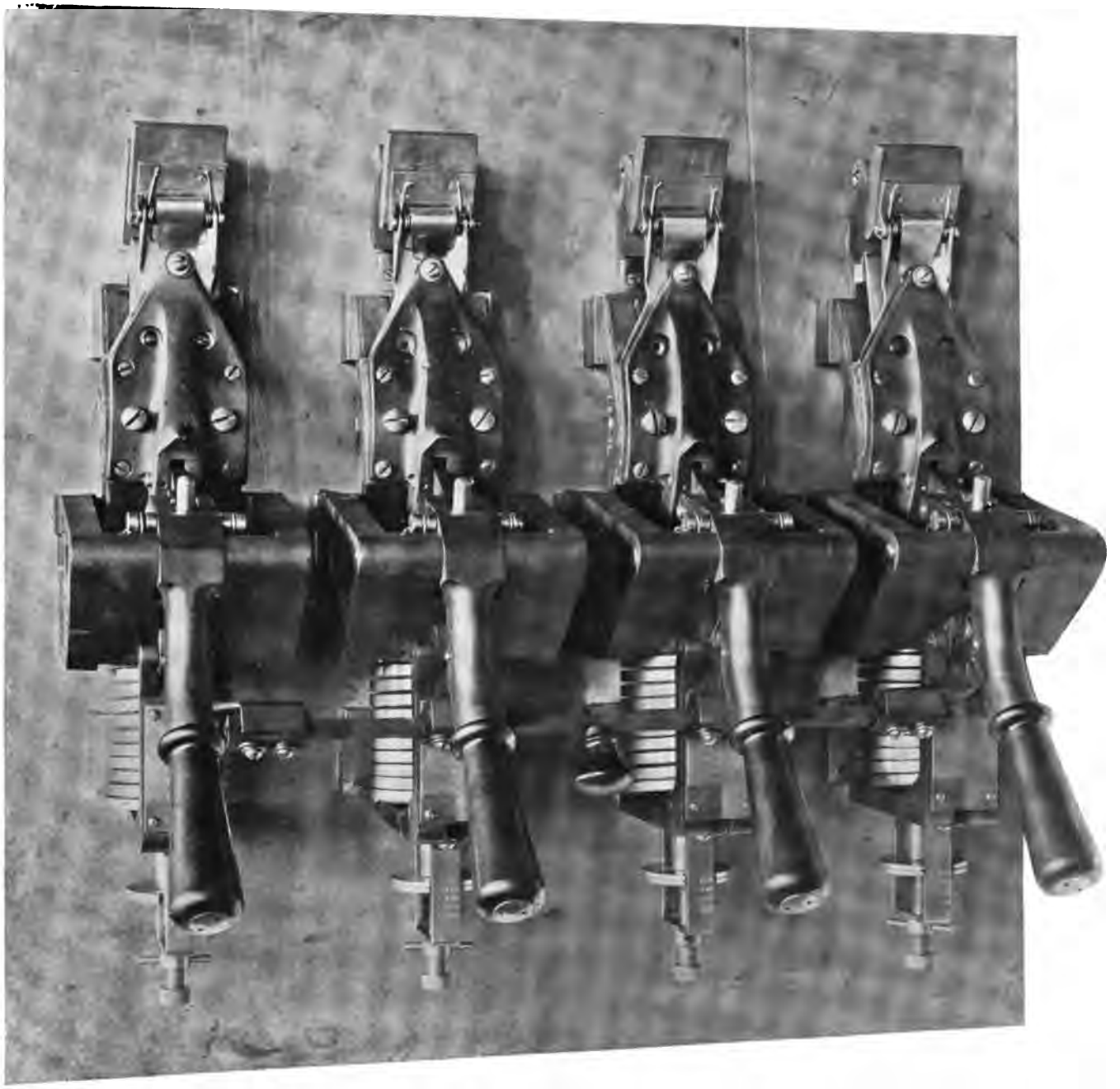
A perfect instrument for the protection of three-phase motors from overload. The switch arms being rigidly united, all three wires are severed simultaneously.

This instrument is also well adapted for the protection of Edison three-wire circuits.

Capacities up to 300 amperes.

Voltages up to 250 direct and 450 alternating current.

Other types for larger capacities or higher voltages.



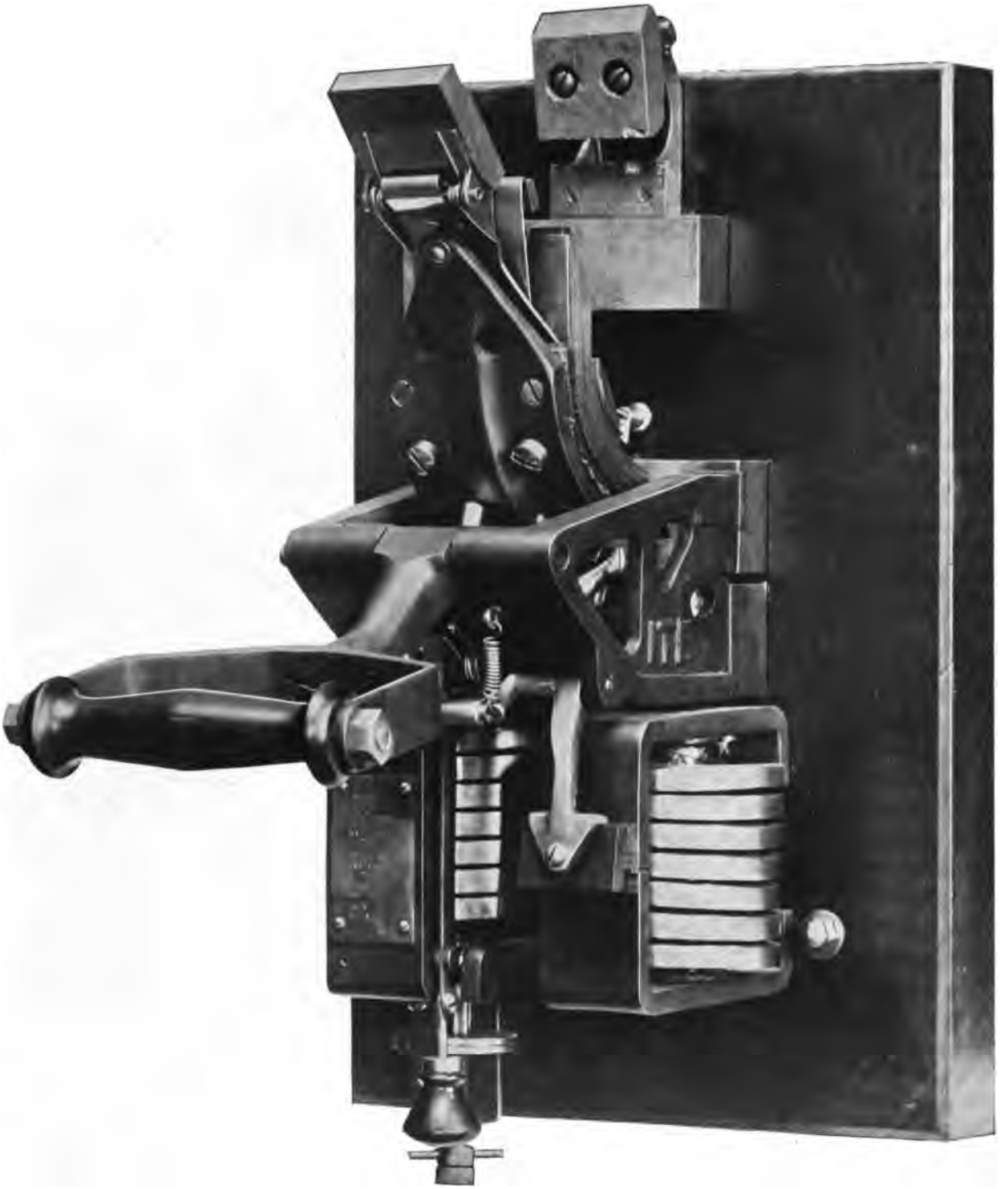
FOUR POLE I-T-E CIRCUIT BREAKER

For the protection of multi-voltage "balancing transformers" and circuits. The switch arms may be made rigidly connected or, as in the illustration, independent, in which case the restraining latches are united, so that in opening the switches act in unison; thus an overload in any one of the four wires causes the severance of all.

Capacities, from 5 to 1500 amperes

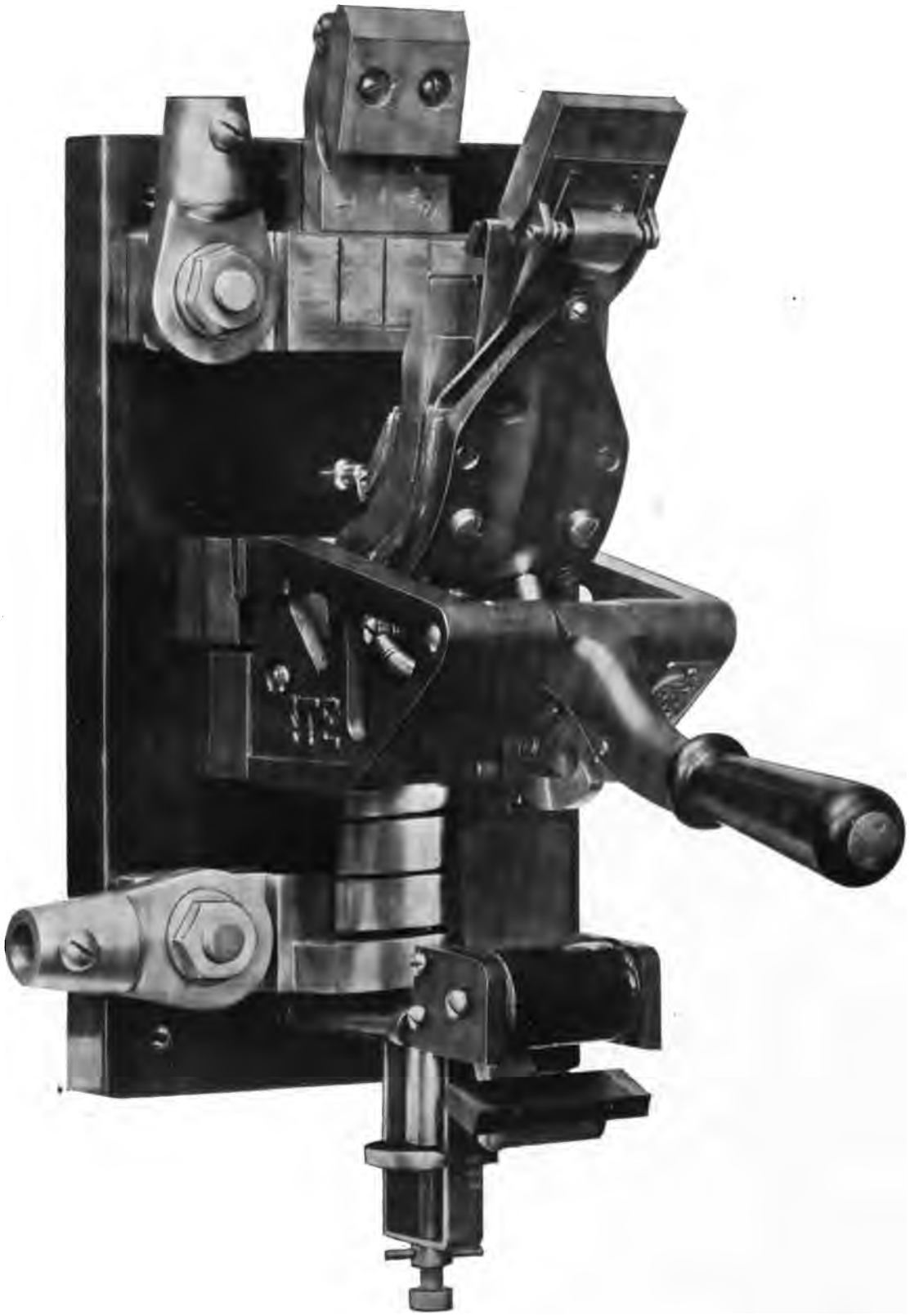
Any voltage up to 750.

The illustration shows the instrument on its temporary slate base.



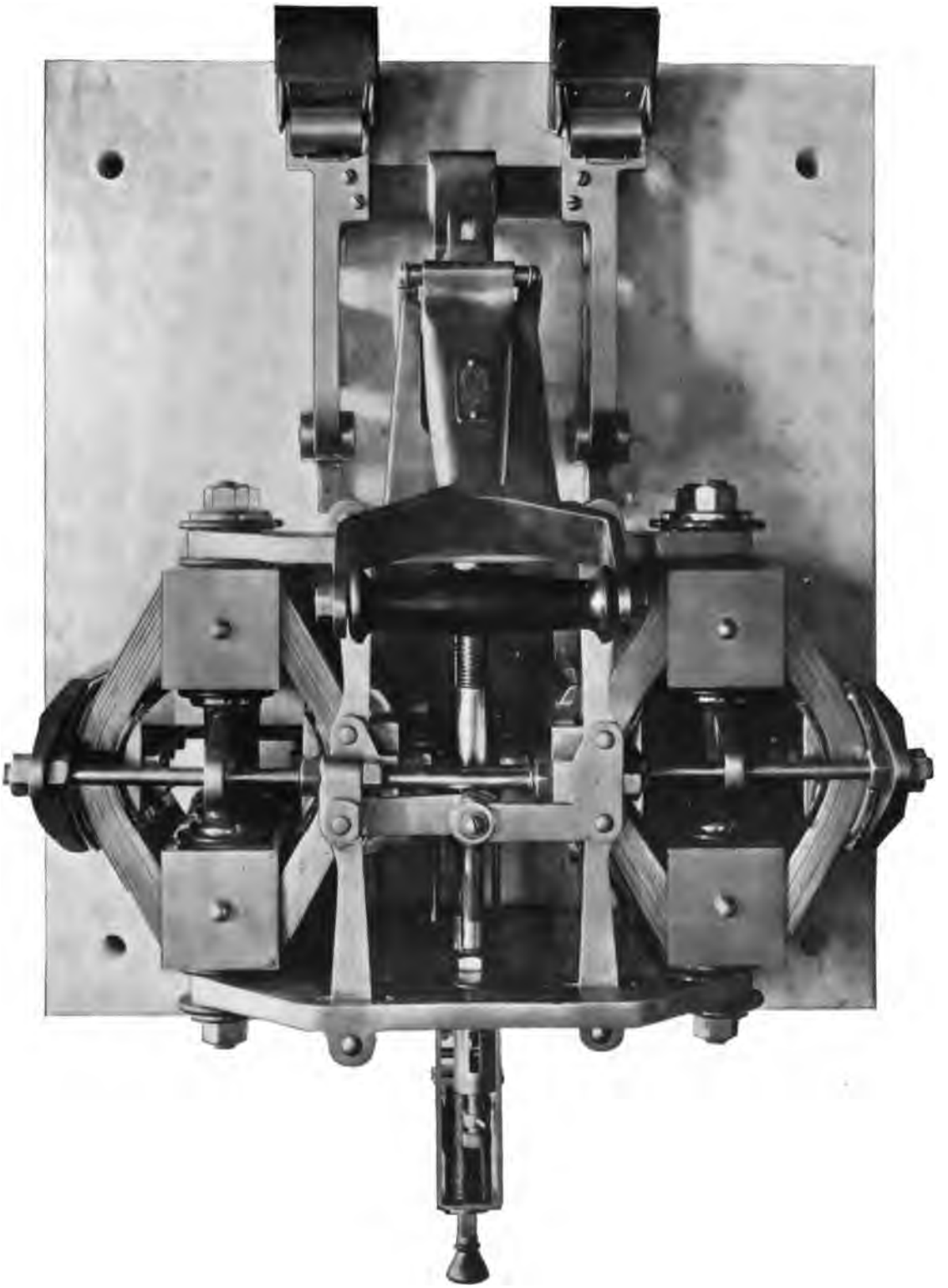
SINGLE POLE "I-T-E LAMINATED" CIRCUIT BREAKER

Operating upon overload or upon reversal in the direction of the current. An instrument particularly adapted for the protection of generators, operating in parallel, booster sets or storage batteries.



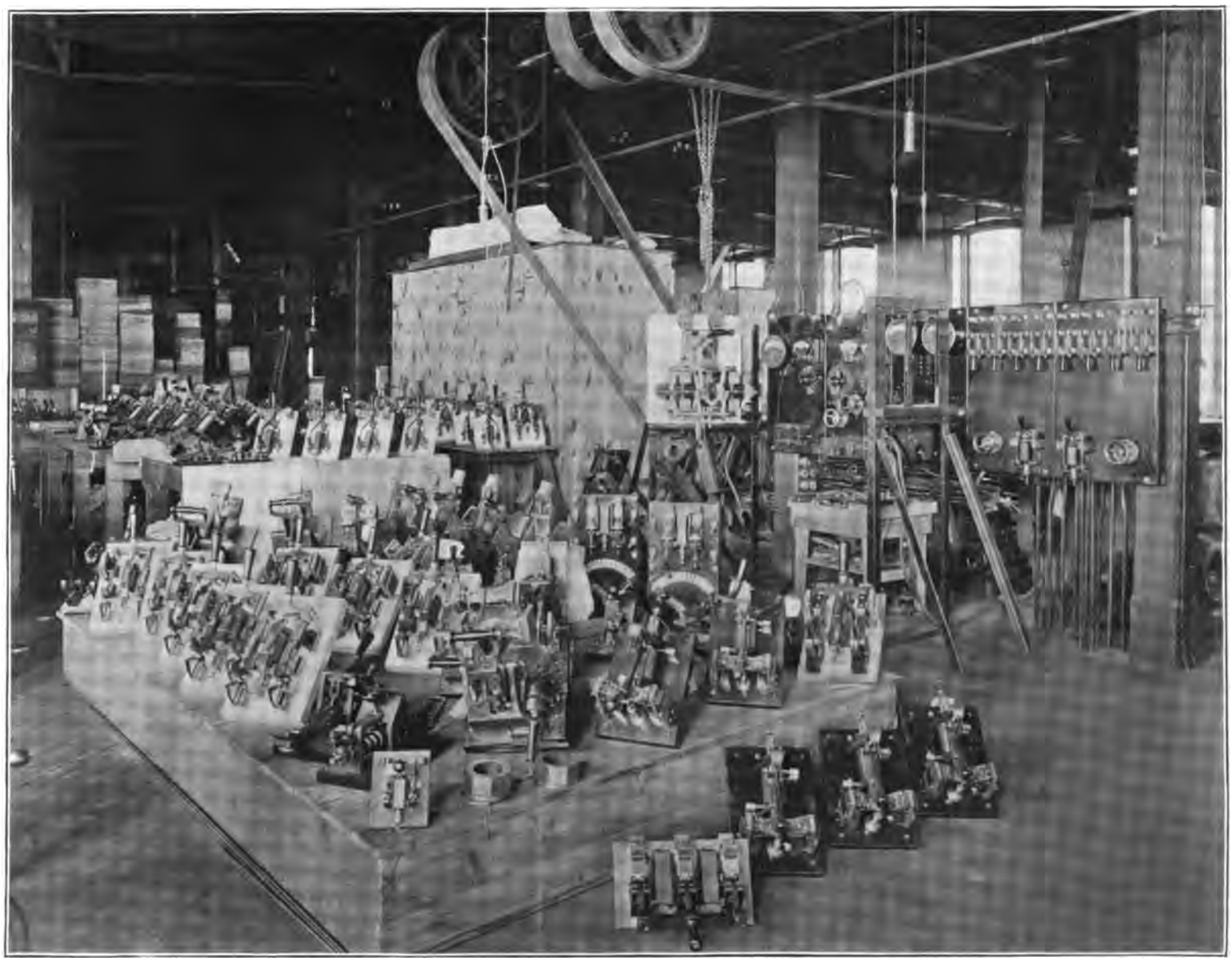
SINGLE POLE "I-T-E LAMINATED" CIRCUIT BREAKER
PROVIDED WITH "FRONT CONNECTIONS"

The cut shows an instrument operating upon overload or upon cessation of line pressure, affording complete protection for motor circuits or individual motors.



I-T-E DOUBLE POLE OVERLOAD CIRCUIT BREAKER

10,000 Amperes Capacity
250 Volts
One of our many special designs to meet special requirements



LABORATORY WHERE I-T-E CIRCUIT BREAKERS ARE TESTED

We build all the instruments we list, and test all we build

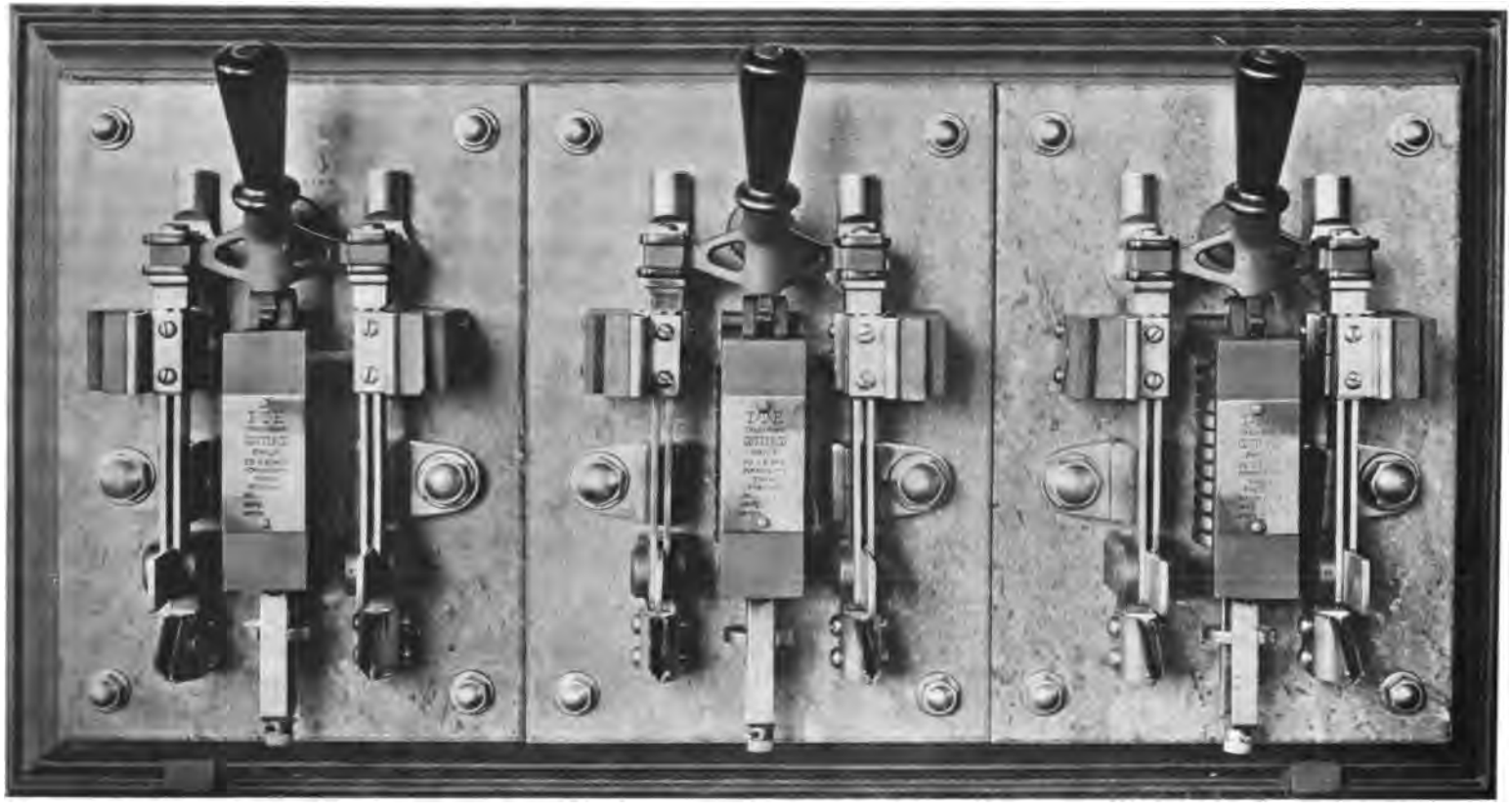
Each calibration mark on every I-T-E is the result of a carefully made test

METRIC EQUIVALENTS OF INCHES AND FRACTIONS THEREOF

Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.
1/32"	.079	1 1/32"	2.619	2 1/32"	5.159	3 1/32"	7.699	4 1/32"	10.239	5 1/32"	12.779	6 1/32"	15.319	7 1/32"	17.859	8 1/32"	20.399	9 1/32"	22.939
1/16"	.159	1 1/16"	2.698	2 1/16"	5.239	3 1/16"	7.779	4 1/16"	10.319	5 1/16"	12.859	6 1/16"	15.399	7 1/16"	17.939	8 1/16"	20.479	9 1/16"	23.019
3/32"	.238	1 3/32"	2.778	2 3/32"	5.318	3 3/32"	7.858	4 3/32"	10.398	5 3/32"	12.938	6 3/32"	15.478	7 3/32"	18.018	8 3/32"	20.558	9 3/32"	23.098
1/8"	.317	1 1/8"	2.857	2 1/8"	5.397	3 1/8"	7.937	4 1/8"	10.477	5 1/8"	13.017	6 1/8"	15.557	7 1/8"	18.097	8 1/8"	20.637	9 1/8"	23.177
5/32"	.397	1 5/32"	2.937	2 5/32"	5.477	3 5/32"	8.017	4 5/32"	10.557	5 5/32"	13.097	6 5/32"	15.037	7 5/32"	18.177	8 5/32"	20.717	9 5/32"	23.257
3/16"	.476	1 3/16"	3.016	2 3/16"	5.556	3 3/16"	8.096	4 3/16"	10.636	5 3/16"	13.176	6 3/16"	15.716	7 3/16"	18.256	8 3/16"	20.796	9 3/16"	23.336
7/32"	.556	1 7/32"	3.095	2 7/32"	5.635	3 7/32"	8.175	4 7/32"	10.715	5 7/32"	13.255	6 7/32"	15.795	7 7/32"	18.335	8 7/32"	20.875	9 7/32"	23.415
1/4"	.635	1 1/4"	3.174	2 1/4"	5.714	3 1/4"	8.254	4 1/4"	10.794	5 1/4"	13.334	6 1/4"	15.874	7 1/4"	18.414	8 1/4"	20.954	9 1/4"	23.494
9/32"	.714	1 9/32"	3.254	2 9/32"	5.794	3 9/32"	8.334	4 9/32"	10.874	5 9/32"	13.414	6 9/32"	15954	7 9/32"	18.494	8 9/32"	21.034	9 9/32"	23.574
5/16"	.794	1 5/16"	3.333	2 5/16"	5.873	3 5/16"	8.413	4 5/16"	10.953	5 5/16"	13.493	6 5/16"	16.033	7 5/16"	18.573	8 5/16"	21.113	9 5/16"	23.653
11/32"	.873	1 11/32"	3.412	2 11/32"	5.952	3 11/32"	8.492	4 11/32"	11.032	5 11/32"	13572	6 11/32"	16.112	7 11/32"	18.652	8 11/32"	21.192	9 11/32"	23.732
3/8"	.952	1 3/8"	3.492	2 3/8"	6.032	3 3/8"	8.572	4 3/8"	11.112	5 3/8"	13.652	6 3/8"	16.192	7 3/8"	18.732	8 3/8"	21.272	9 3/8"	23.812
13/32"	1.032	1 13/32"	3.570	2 13/32"	6.111	3 13/32"	8.651	4 13/32"	11.191	5 13/32"	13.731	6 13/32"	16.271	7 13/32"	18.811	8 13/32"	21.351	9 13/32"	23.891
7/16"	1.111	1 7/16"	3.650	2 7/16"	6.190	3 7/16"	8.730	4 7/16"	11.270	5 7/16"	13.810	6 7/16"	16.350	7 7/16"	18.890	8 7/16"	21.420	9 7/16"	23.970
15/32"	1.191	1 15/32"	3.730	2 15/32"	6.270	3 15/32"	8.810	4 15/32"	11.350	5 15/32"	13.890	6 15/32"	16.430	7 15/32"	18.970	8 15/32"	21.510	9 15/32"	24.050
1/2"	1.270	1 1/2"	3.809	2 1/2"	6.349	3 1/2"	8.889	4 1/2"	11.429	5 1/2"	13.969	6 1/2"	16.509	7 1/2"	19.049	8 1/2"	21.589	9 1/2"	24.129
17/32"	1.350	1 17/32"	3.888	2 17/32"	6.428	3 17/32"	8.968	4 17/32"	11.508	5 17/32"	14.048	6 17/32"	16.588	7 17/32"	19.128	8 17/32"	21.668	9 17/32"	24.208
9/16"	1.430	1 9/16"	3.967	2 9/16"	6.507	3 9/16"	9.047	4 9/16"	11.587	5 9/16"	14.127	6 9/16"	16.667	7 9/16"	19.207	8 9/16"	21.747	9 9/16"	24.287
19/32"	1.510	1 19/32"	4.047	2 19/32"	6.587	3 19/32"	9.127	4 19/32"	11.667	5 19/32"	14.207	6 19/32"	16.747	7 19/32"	19.287	8 19/32"	21.827	9 19/32"	24.367
5/8"	1.590	1 5/8"	4.126	2 5/8"	6.666	3 5/8"	9.206	4 5/8"	11.746	5 5/8"	14.286	6 5/8"	16.826	7 5/8"	19.366	8 5/8"	21.906	9 5/8"	24.446
21/32"	1.670	1 21/32"	4.205	2 21/32"	5.745	3 21/32"	9.285	4 21/32"	11.825	5 21/32"	14.365	6 21/32"	16.905	7 21/32"	19.445	8 21/32"	21.985	9 21/32"	24.525
11/16"	1.750	1 11/16"	4.284	2 11/16"	6.825	3 11/16"	9.365	4 11/16"	11.905	5 11/16"	14.445	6 11/16"	16.985	7 11/16"	19.525	8 11/16"	22.065	9 11/16"	24.605
23/32"	1.830	1 23/32"	4.364	2 23/32"	6.904	3 23/32"	7.494	4 23/32"	11.984	5 23/32"	14.524	6 23/32"	17.064	7 23/32"	19.604	8 23/32"	22.144	9 23/32"	24.584
3/4"	1.900	1 3/4"	4.443	2 3/4"	6.983	3 3/4"	9.523	4 3/4"	12.063	5 3/4"	14.603	6 3/4"	17.143	7 3/4"	19.683	8 3/4"	22.223	9 3/4"	24.763
25/32"	1.980	1 25/32"	4.522	2 25/32"	7.063	3 25/32"	9.603	4 25/32"	12.143	5 25/32"	14.683	6 25/32"	17.223	7 25/32"	19.763	8 25/32"	22.303	9 25/32"	24.843
13/16"	2.060	1 13/16"	4.602	2 13/16"	2.142	3 13/16"	9.682	4 13/16"	12.222	5 13/16"	14.762	6 13/16"	17.302	7 13/16"	19.842	8 13/16"	22.382	9 13/16"	24.922
27/32"	2.140	1 27/32"	4.681	2 27/32"	7.221	3 27/32"	9.761	4 27/32"	12.301	5 27/32"	14.841	6 27/32"	17.381	7 27/32"	19.921	8 27/32"	22.461	9 27/32"	25.001
7/8"	2.220	1 7/8"	4.760	2 7/8"	7.300	3 7/8"	9.840	4 7/8"	12.380	5 7/8"	14.920	6 7/8"	17.460	7 7/8"	20.000	8 7/8"	22.540	9 7/8"	25.080
29/32"	2.300	1 29/32"	4.840	2 29/32"	7.380	3 29/32"	9.920	4 29/32"	12.460	5 29/32"	15.000	6 29/32"	17.540	7 29/32"	20.080	8 29/32"	22.620	9 29/32"	25.160
15/16"	2.380	1 15/16"	4.919	2 15/16"	7.459	3 15/16"	9.999	4 15/16"	12.539	5 15/16"	15.079	6 15/16"	17.619	7 15/16"	20.159	8 15/16"	22.699	9 15/16"	25.239
31/32"	2.460	1 31/32"	4.998	2 31/32"	7.538	3 31/32"	10.078	4 31/32"	12.618	5 31/32"	15158	6 31/32"	17.698	7 31/32"	20.238	8 31/32"	22.778	9 31/32"	25.318
1"	2.540	2"	5.080	3"	7.620	4"	10.160	5"	12.700	6"	15.240	7"	17.780	8"	20.320	9"	22.860	10"	25.400

METRIC EQUIVALENTS OF INCHES AND FRACTIONS THEREOF

Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.	Inches.	Centi-metres.
10 1/32"	25.479	11 1/32"	28.019	12 1/32"	30.559	13 1/32"	33.099	14 1/32"	35.639	15 1/32"	38.179	16 1/32"	40.719	17 1/32"	43.259	18 1/32"	45.799	19 1/32"	48.339
10 1/16"	25.559	11 1/16"	28.099	12 1/16"	30.639	13 1/16"	33.179	14 1/16"	35.719	15 1/16"	38.259	16 1/16"	40.799	17 1/16"	43.339	18 1/16"	45.879	19 1/16"	48.419
10 3/32"	25.638	11 3/32"	28.178	12 3/32"	30.718	13 3/32"	33.258	14 3/32"	35.798	15 3/32"	38.338	16 3/32"	40.878	17 3/32"	43.418	18 3/32"	45.958	19 3/32"	48.498
10 1/8"	25.717	11 1/8"	28.257	12 1/8"	30.797	13 1/8"	33.337	14 1/8"	35.877	15 1/8"	38.417	16 1/8"	40.957	17 1/8"	43.497	18 1/8"	46.037	19 1/8"	48.577
10 5/32"	25.797	11 5/32"	28.337	12 5/32"	30.877	13 5/32"	33.417	14 5/32"	35.957	15 5/32"	38.497	16 5/32"	41.037	17 5/32"	43.577	18 5/32"	46.117	19 5/32"	48.657
10 3/16"	25.876	11 3/16"	28.416	12 3/16"	30.956	13 3/16"	33.496	14 3/16"	36.036	15 3/16"	38.576	16 3/16"	41.116	17 3/16"	43.656	18 3/16"	46.196	19 3/16"	48.736
10 7/32"	25.955	11 7/32"	28.495	12 7/32"	31.035	13 7/32"	33.575	14 7/32"	36.115	15 7/32"	38.655	16 7/32"	41.195	17 7/32"	43.735	18 7/32"	46.275	19 7/32"	48.815
10 1/4"	26.034	11 1/4"	28.574	12 1/4"	31.114	13 1/4"	33.654	14 1/4"	36.194	15 1/4"	38.734	16 1/4"	41.274	17 1/4"	43.814	18 1/4"	46.354	19 1/4"	48.894
10 9/32"	26.114	11 9/32"	28.654	12 9/32"	31.194	13 9/32"	33.734	14 9/32"	36.274	15 9/32"	38.814	16 9/32"	41.354	17 9/32"	43.894	18 9/32"	46.434	19 9/32"	48.974
10 5/16"	26.193	11 5/16"	28.733	12 5/16"	31.273	13 5/16"	33.813	14 5/16"	36.353	15 5/16"	38.893	16 5/16"	41.433	17 5/16"	43.973	18 5/16"	46.513	19 5/16"	49.053
10 11/32"	26.272	11 11/32"	28.812	12 11/32"	31.352	13 11/32"	33.892	14 11/32"	36.432	15 11/32"	38.972	16 11/32"	41.512	17 11/32"	44.052	18 11/32"	46.592	19 11/32"	49.132
10 3/8"	26.352	11 3/8"	28.892	12 3/8"	31.432	13 3/8"	33.972	14 3/8"	36.512	15 3/8"	39.052	16 3/8"	41.592	17 3/8"	44.132	18 3/8"	46.672	19 3/8"	49.212
10 13/32"	26.431	11 13/32"	28.971	12 13/32"	31.511	13 13/32"	34.051	14 13/32"	36.591	15 13/32"	39.131	16 13/32"	41.671	17 13/32"	44.211	18 13/32"	46.751	19 13/32"	49.291
10 7/16"	26.510	11 7/16"	29.050	12 7/16"	31.590	13 7/16"	34.130	14 7/16"	36.670	15 7/16"	39.210	16 7/16"	41.750	17 7/16"	44.290	18 7/16"	46.830	19 7/16"	49.370
10 15/32"	26.560	11 15/32"	29.130	12 15/32"	31.670	13 15/32"	34.210	14 15/32"	36.750	15 15/32"	39.290	16 15/32"	41.830	17 15/32"	44.370	18 15/32"	46.910	19 15/32"	49.450
10 1/2"	26.669	11 1/2"	29.209	12 1/2"	31.749	13 1/2"	34.289	14 1/2"	36.829	15 1/2"	39.369	16 1/2"	41.909	17 1/2"	44.449	18 1/2"	46.989	19 1/2"	49.529
10 17/32"	26.748	11 17/32"	29.288	12 17/32"	31.828	13 17/32"	34.368	14 17/32"	36.908	15 17/32"	39.448	16 17/32"	41.988	17 17/32"	44.528	18 17/32"	47.068	19 17/32"	49.608
10 9/16"	26.827	11 9/16"	29.367	12 9/16"	31.907	13 9/16"	34.447	14 9/16"	36.987	15 9/16"	39.527	16 9/16"	42.067	17 9/16"	44.607	18 9/16"	47.147	19 9/16"	49.687
10 19/32"	26.907	11 19/32"	29.447	12 19/32"	31.987	13 19/32"	34.527	14 19/32"	37.067	15 19/32"	39.607	16 19/32"	42.147	17 19/32"	44.687	18 19/32"	47.227	19 19/32"	49.767
10 5/8"	26.986	11 5/8"	29.526	12 5/8"	32.066	13 5/8"	34.606	14 5/8"	37.146	15 5/8"	39.686	16 5/8"	42.226	17 5/8"	44.766	18 5/8"	47.306	19 5/8"	49.846
10 21/32"	27.065	11 21/32"	29.605	12 21/32"	32.145	13 21/32"	34.685	14 21/32"	37.225	15 21/32"	39.765	16 21/32"	42.305	17 21/32"	44.845	18 21/32"	47.385	19 21/32"	49.925
10 11/16"	27.145	11 11/16"	29.685	12 11/16"	32.225	13 11/16"	34.765	14 11/16"	37.305	15 11/16"	39.845	16 11/16"	42.385	17 11/16"	44.925	18 11/16"	47.465	19 11/16"	50.005
10 23/32"	27.224	11 23/32"	29.764	12 23/32"	32.304	13 23/32"	34.844	14 23/32"	37.384	15 23/32"	39.924	16 23/32"	42.464	17 23/32"	45.004	18 23/32"	47.544	19 23/32"	50.084
10 3/4"	27.303	11 3/4"	29.843	12 3/4"	32.383	13 3/4"	34.923	14 3/4"	37.463	15 3/4"	40.003	16 3/4"	42.543	17 3/4"	45.083	18 3/4"	47.623	19 3/4"	50.163
10 25/32"	27.383	11 25/32"	29.923	12 25/32"	32.403	13 25/32"	35.003	14 25/32"	37.543	15 25/32"	40.083	16 25/32"	42.623	17 25/32"	45.163	18 25/32"	47.703	19 25/32"	50.243
10 13/16"	27.462	11 13/16"	30.002	12 13/16"	32.542	13 13/16"	35.082	14 13/16"	37.622	15 13/16"	40.162	16 13/16"	42.702	17 13/16"	45.242	18 13/16"	47.782	19 13/16"	50.322
10 27/32"	27.541	11 27/32"	30.081	12 27/32"	32.621	13 27/32"	35.161	14 27/32"	37.701	15 27/32"	40.241	16 27/32"	42.781	17 27/32"	45.321	18 27/32"	47.861	19 27/32"	50.401
10 7/8"	27.620	11 7/8"	30.160	12 7/8"	32.700	13 7/8"	35.240	14 7/8"	37.780	15 7/8"	40.320	16 7/8"	42.860	17 7/8"	45.400	18 7/8"	47.940	19 7/8"	50.480
10 29/32"	27.700	11 29/32"	30.240	12 29/32"	32.780	13 29/32"	35.320	14 29/32"	37.860	15 29/32"	40.400	16 29/32"	42.940	17 29/32"	45.480	18 29/32"	48.020	19 29/32"	50.560
10 15/16"	27.779	11 15/16"	30.319	12 15/16"	32.859	13 15/16"	35.409	14 15/16"	37.939	15 15/16"	40.479	16 15/16"	43.019	17 15/16"	45.559	18 15/16"	48.099	19 15/16"	50.639
10 31/32"	27.858	11 31/32"	30.398	12 31/32"	32.938	13 31/32"	35.478	14 31/32"	38.018	15 31/32"	40.558	16 31/32"	43.098	17 31/32"	45.638	18 31/32"	48.178	19 31/32"	50.718
11"	27.940	12"	30.480	13"	33.020	14"	35.560	15"	38.100	16"	40.640	17"	43.180	18"	45.720	19"	48.260	20"	50.800



DISTRIBUTING CENTRE IN THE NEW GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The illustration on page 87 shows a distributing centre in the old Printing Office. The following paper, on the Use of Circuit Breakers in Power Transmission, is reprinted from "Modern Switchboards," in order that we may accommodate our customers whom we have recently been unable to supply.

CIRCUIT BREAKERS AND THEIR USE IN POWER TRANSMISSION

By W. H. TAPLEY

Chief Electrician U. S. Government Printing Office, Washington, D. C.

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When the application of individual electric motors to driving machinery became firmly established in the manufacturing world, and was conceded to be a more economical method of power transmission than belting with long lines of shafting, second only to the motor, and how properly to connect it to the machine which it was to operate, was the subject of suitable protection both to motor and machine.

The first thing that suggested itself, and naturally, was to protect the motor in the same way as lighting circuits, namely, to introduce a suitable fuse. This was done, and where motors were belted the results attending overloads were rather of an annoying and aggravating nature than anything which could really be called serious; yet when gearing and the direct application of armature to the main driving shaft of a machine began to supersede the belt, it was only a short time before the fact that a fuse was not an adequate protection became forcibly impressed upon the advocates of electrical power transmission.

As the art advanced, the thing to which the electrical engineer would turn for a rational solution of the problem was the electric current itself. How well this has been accomplished is shown by

the successful introduction of the circuit breaker, now so universally used in all large power plants. That the magnetic property of the electric current was the means best adapted for the actuation of the protective device, and gravitation the most reliable force for governing its operation, is seen by the great superiority of the circuit breaker which depends entirely upon these forces, over those in which the effect of the actuating current is subject to variation due to extraneous conditions.

PROTECTION AND WHAT IT SHOULD BE, AS APPLIED TO A LARGE MANUFACTURING PLANT

In treating of this subject the tendency of the engineer has been to regard it almost entirely from an electrical point of view, incidentally, if at all, considering that which affected the real success of the manufacturing establishment employing motors, namely, constant service and lowest cost of production. Before entering further into this matter, let us see what is absolutely required to give a manufacturing establishment protection worthy of that name, when using electrical power transmission.

First—To secure the protection of electrical apparatus from motor to generator.

Second—To provide a method which will afford ample protection for the machinery to which electric motors are attached.

Third—To secure a freedom from interruption of production, and avoid the exasperating delay which is experienced in replacing any part of the protective device after the same has been called into service.

Fourth—After protecting everything in the shape of machinery, the safety of building and electrical apparatus and providing

against the stoppage of production, the matter of reducing to the lowest possible point the liability of accident to the operators required to handle either motors or machinery must be considered, as indeed this is a matter of supreme importance.

That all the above-mentioned features are ever present, confronting the engineer, who is responsible for the successful operation of a manufacturing plant, is confirmed by the large number of so-called protective devices already offered to the public.

At present a very large part of the labor of the electrical engineer and the manufacturers of this kind of electrical apparatus has been directly in one line, that of protecting the electrical apparatus from the effects of overheating and the building from fires which might occur from heavily overloaded circuits.

As this feature is commanding a large share of attention in the electrical press and manufacturing world, it would seem best to devote our time in this article to the field suggested in the last three of the foregoing propositions, which, if satisfactorily solved, of necessity cover all the ground now under consideration by engineers, on the subject of proper and positive protection to electrical apparatus as applied to transmission of power.

The pronounced success during the past two or three years of the direct application of electric motors to all kinds of machinery has put this method of power supply so far in advance of other methods that, notwithstanding the comparatively high first cost, it is now considered the most economical method, and should be adopted by every large manufacturing plant where the work is, in any sense, of an intermittent nature.

Let us now look from the electrical side to that of the manufacturing plant proper, and see if protection is not even more important and imperative here, where very much larger sums of money are invested, and until now have been wholly neglected except by insurance from fire.

To suggest something which may form a topic for discussion, let us take the case of a printing-press to which is directly connected an electric motor. The cost of the printing-press is, roughly speaking, $3,000.00, and that of the motor equipment $300.00. (These are nominal figures, which vary with the class of press used and character of work required from it; the cost of motors also varies considerably, but these figures are conservative and fully within the figures for which good apparatus can be purchased.) Allowing the electrical to be one-tenth the cost of the mechanical installation, does it not seem strange that it has always been the motor which it has been the sole idea of the engineer to protect, notwithstanding its cost is insignificant as compared with the value of the machine to which it is attached? Is it any wonder that the manufacturers of costly machinery, such as printing-presses, have looked with doubtful eye upon the method of direct motor application, whether it be by gearing or having the armature of the motor keyed to the main shaft of the press? The manufacturer well knew that for a

short time the motor was capable of producing perhaps five times its rated output, and realized that if this period covered only a few seconds, there was a great probability that it would be sufficient to ruin the press should anything occur which would tend to stop it suddenly. He did not feel that there was even the protection which is afforded the presses when driven by belts, for these would slip when called upon to do much more than the normal work of driving the press.

The writer takes the same ground as the machinery builder, and when the representatives of companies manufacturing electrical apparatus were asked about this matter, they invariably assured the purchaser that a fuse inserted in the circuit supplying the motor with current would provide against all possible trouble of this kind. It was tried; the fuse worked in some cases and we began to take courage, thinking that perhaps we were too particular and that the fuse afforded the required protection. It was seen, however, that the blowing of the fuse might serve to protect the motor but not the press.

It is impossible to change over from one method of operating machinery to another without meeting failures, due perhaps to nervousness on the part of the operator when called upon to do a thing for the first time; and certainly it was so when motors were first used in this manner. The sudden turning on of the controller naturally blew the fuse, which too often was sufficiently increased in size to prevent this annoyance. But at its best the fuse served only to protect the motor, the requirements of the motor-driven machine being altogether overlooked. To better appreciate the shortcomings of the fuse in this respect, it is only necessary to understand the conditions under which it operates to open the circuit in which it may be placed.

The effective energy which must be supplied to the fuse is made up of the following quantities: First, heat sufficient to raise the temperature to that of the melting point of the fuse; and second, an additional amount of heat proportional to the mass and latent heat of fusion of the fuse, while in addition to this, the heat, being radiated by the fuse and its terminals, must be supplied. It will be seen from a consideration of these facts that the fuse requiring a relatively large excess of energy to effect its operation will permit a proportional excess of power to be supplied to the motor. The damage which may result from this may perhaps be more readily seen by an example. Suppose a foreign body gets into the working parts of a machine which is directly connected to a motor. The power supplied by the motor is now expended in the wrecking of the machine, the weakest parts yielding first to the strain. Only a very short time is necessary for the execution of great damage. The possibility of damage is then limited only by the energy required to blow the fuse.

It was only upon the advent of the modern circuit breaker that protection worthy the name was secured for motor-driven machinery. Owing to the much lessened energy required in the operation of this device, the time required, upon the occurrence of an abnormal flow, for the opening of the circuit is minimized, while, in addition to this, the heavier overloads are made to contribute some of their energy to the acceleration of the circuit-opening switch, thereby still further decreasing the time of opening.

It may thus be seen that by the use of a properly constructed circuit breaker the excess of power which may be communicated to the machine is vastly reduced as compared with the fuse. In fact, the time element is so lessened that the possibility of damage

to machine as well as to motor is practically limited to that due to their combined momentum. What this is in each individual case makes it necessary to decide whether an auxiliary break to take care of the same is necessary or not. This is a question for the mechanical engineer to solve; but whatever this may be, it does not affect the principles set forth above, and only serves to bring out more clearly how necessary it is to shut off the current instantly and thus prevent the machine from acquiring any additional momentum.

As the question of machinery protection has been given so little consideration, it was deemed advisable to bring to the reader's notice, in rather a minute way, all the possibilities that it may have, in order to give to the subject the importance which we feel it deserves. In the foregoing, a reference was made to the comparative cost of a printing-press and that of the necessary electrical equipment to drive the same; *i. e.*, $3,000.00 for the former and $300.00 for the latter—a relative value of ten to one, which justifies the statement that the protection of machinery is a much more important consideration in electrical transmission than that of the motor. Can the electrical engineer afford to neglect this important feature of machinery protection and still hope that his customer will secure satisfactory results? for, after all, it is necessary that the new system, as a whole, shall be made more productive, and thereby more profitable, than the old.

It may be assumed that our third proposition is intended more especially for the manufacturer than the engineer; but, taking the ground that that which is of importance to the buyer concerns the seller also, we believe it is worthy of the close attention of both. As the writer has had an extended experience upon the application

of electricity to printing machinery, he hopes to be able to treat this branch of a manufacturing business in a more positive manner than he could do should he endeavor to extend its scope into a more general or theoretical field.

Referring once again to the printing-press, with its electrical equipment cost (which we assume to be respectively $3,000.00 and $300.00), let us see what the production of such a press should be when it is running for three hundred days in the year on a fairly good class of printing, and what costly affairs stoppages of presses are, no matter what the cause. A press should earn an average of $10.00 a day, or $3,000.00 a year. This is not intended to express net earnings, but simply the average gross earnings for the press on commercial work, and we assume that it is running on such work continuously. It will be seen that delays caused by an accident to a press may prove much more expensive to the printer than the actual cost of the repairs to the press itself, as a delay of a week means a loss of $10.00 a day, or $60.00; and serious accidents often mean a month of working days, or $260.00, aside from the cost of repairs, which experience has shown are not to be lightly considered.

Nor is it to be forgotten that the press to which an accident usually occurs is generally running on a piece of work which must be completed within a given time. This means that we must lift the form and place it upon another press which has to be "made ready," perhaps interfering with other work, and all this additional cost must be borne by the manufacturer without any return for the same. Is not the manufacturer fully justified, then, in demanding that his machinery and output be equally considered with that of the electrical apparatus in the matter of protection?

If the protection of apparatus worth $300.00 is deemed so important as to occupy, as it undoubtedly does, the attention of the foremost electrical engineers, are we not justified in taking the position that protective devices should be so constructed as to fully protect the manufacturer at all points, and not stop with the electrical equipment alone?

By the use of the highest-grade circuit breaker now offered to the public, which fulfils in a very satisfactory manner all the requirements thus far considered, such a saving may be made, not only to the motor, but to the machine which it drives, that the loss occasioned by stoppages and on account of repairs will be practically eliminated, and the device will pay for itself many times in the first year.

The delays incident to the blowing and replacement of fuses are perhaps more annoying in newspaper and publishing offices (where mails have to be met and where the time for the completion of a particular piece of work is limited) than in most classes of manufacturing; but in any case the saving is so important as to amount to very much more than the cost of adequate apparatus. Indeed, it would seem to be the best paying insurance which the manufacturer could possibly obtain. Such delays as we have been considering are practically unknown when the fuse is replaced by a thoroughly mechanically and electrically constructed circuit breaker.

With the more universal adoption of the individual motor in electrical power transmission comes also the question of protection to operatives employed in handling the machinery. This is of so much importance that most of the States in this country have appointed inspectors to visit all manufacturing establishments and

see that the proper precautions are used, and every means employed to lessen the danger to the employees, of whatever nature it may be. With all the precaution taken to prevent accidents, it is impossible to do away with them entirely. Strange as it may seem, the carelessness or foolhardiness of the employees themselves is mainly responsible for most of the accidents which occur to-day, thanks to the hearty co-operation of inspectors and employers in their endeavors to make accidents practically impossible. Yet I know of nothing to prevent a man from placing his hands in close proximity to running gears, and if he happens to have a piece of waste in his hands and the same gets caught, the resulting damage is only limited by the quickness with which the machine can be stopped. Several such cases have come under my personal observation, and only the prompt opening of the circuit breaker prevented very serious results. In one case a man's fingers were pulled into a train of gears, he endeavoring to clean the press while in motion. His fingers were badly jammed, but the opening of the circuit breaker stopped the press before any serious damage was done, and thus saved the man three fingers. Another case was that of a man who got his arm caught between the two cylinders of a press. He was fixing the packing on one of the cylinders and motioned to the feeder to reverse the press. Instead, she started it ahead suddenly with the result that his arm was drawn in between the revolving cylinders, and again, owing to the instantaneous opening of the circuit breaker the pressman escaped with a severely bruised arm, instead of crushed bones as we had all expected.

These serve as examples upon which to base a requirement that protection to operatives is not a matter of minor importance, and should not be put aside with the remark: "Let the employees keep

their hands out of the machinery—we cannot protect everything and everybody." To be sure, we have no electrical or mechanical device which will make brains for the ignorant or prevent careless operatives from getting hurt; yet devices can be made, as we have seen, which reduce the results of such carelessness to a minimum, and their employment should become more general as the successful operation of them becomes better known.

Having thus considered in detail the protection demanded by a large manufacturing plant using individual motors as the method of power supply, we are confronted with the proposition: can these demands be met to the satisfaction of all concerned—to the builder of machinery, as well as of electrical apparatus, and to the manufacturer using them? If such is the case, what is the device necessary to fulfil the requirements, and is it commercially obtainable?

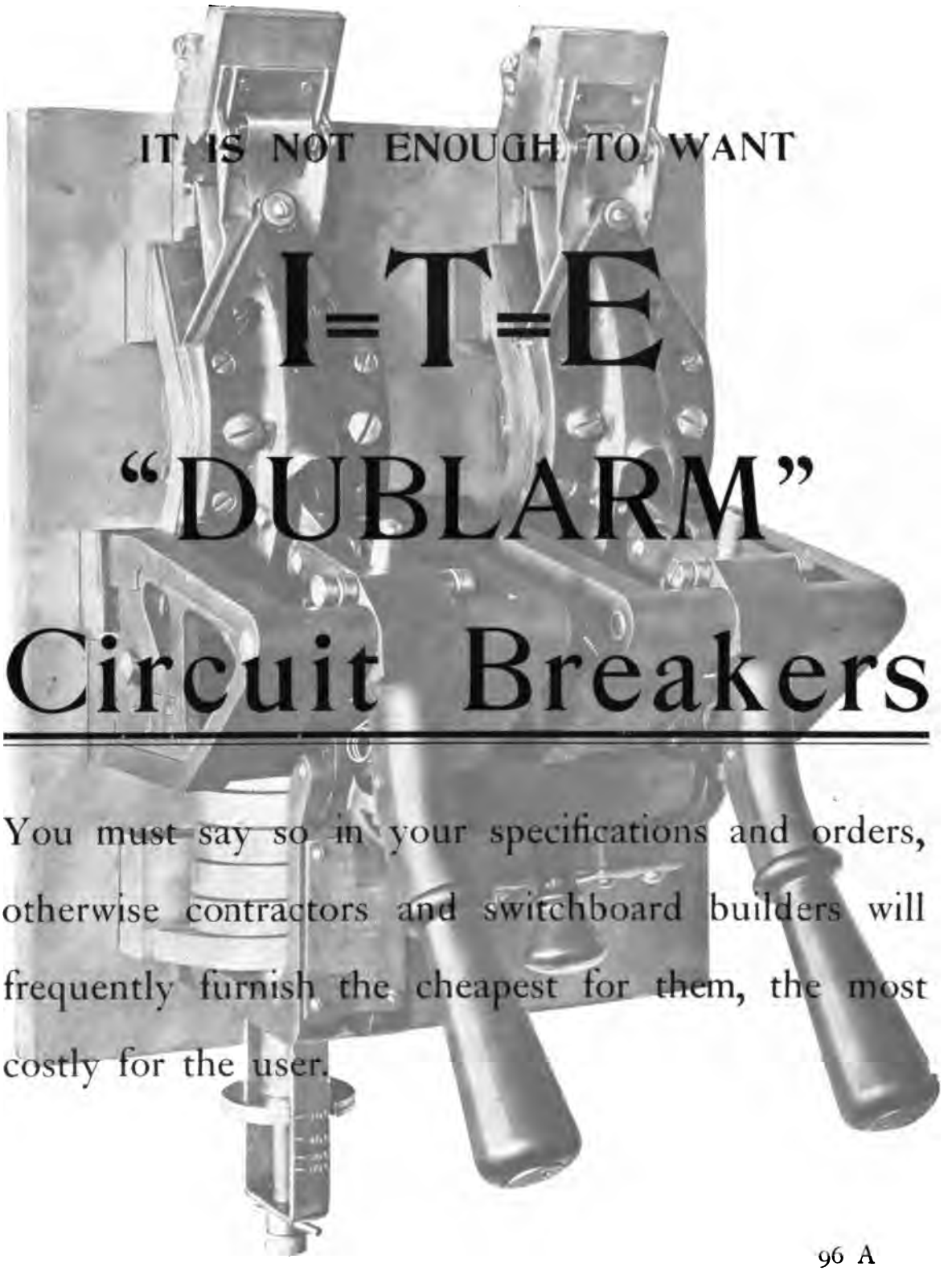
With reference to the fuse, we have only to read any of the scores of valuable papers written upon their action to fully justify us in writing against it "not satisfactory" and passing on. As the current itself may be the means of protection, as well as that of propulsion, the method of opening the circuit electrically should be employed. This has been successfully accomplished in the modern circuit breakers which operate on the inverse time element rather than the constant time limit.

The ultimate requirements of a circuit breaker are that we can rely upon it to do all that we have shown it should do, and operate successfully, not once, twice, or for a month, but always. When this ceases to be the case, the magnetic circuit breaker will be superseded by some other means of protection.

To produce such an instrument the highest skill, electrical and mechanical, is required. Long study of the existing state of the

art and the conditions under which circuit breakers operate is necessary, and the closest attention must be given to every detail of manufacture.

With this an accomplished fact, such results are not the only reward, however, nor should they be. The public will cheerfully pay, not only for the labor and material used in its production, but also a profit sufficient to encourage the maker and enable him to continue the work, for the perfect is never obtainable and is only reached approximately. In electrical science, perhaps more than in any other, we are never able to write the word "Finis."



IT IS NOT ENOUGH TO WANT

I=T=E

"DUBLARM"

Circuit Breakers

You must say so in your specifications and orders, otherwise contractors and switchboard builders will frequently furnish the cheapest for them, the most costly for the user.

I-T-E CIRCUIT BREAKER. "DUBLARM" TYPE

(DOUBLE POLE, DOUBLE ARM)

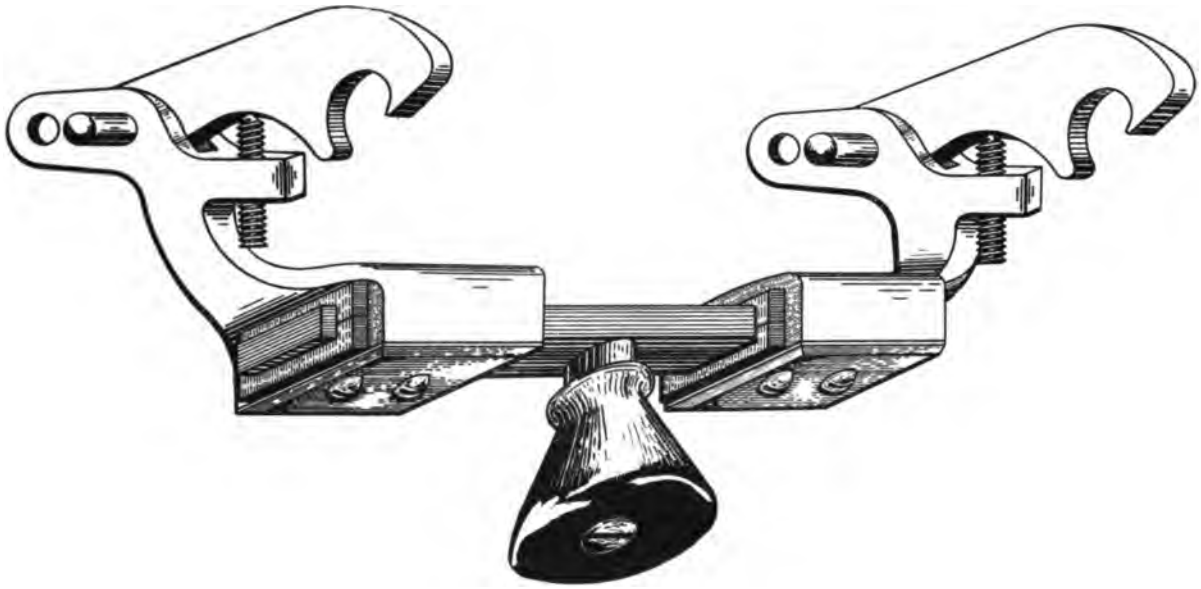
In the switchboard practice of to-day the principles controlling design are simplicity of arrangement, economy of construction, adaptability to requirements and effectiveness in use, and naturally the choice of appliances for the switchboard should also be governed by the same considerations. As far as may be, without sacrificing simplicity, these should be designed so that all possible functions may be embodied in each piece of apparatus. They should be constructed in such a manner that their use is free from liability of accident, even as the result of careless handling. It must be remembered that however skilful the switchboard attendant may be, in an emergency he is liable to error; the arrangement of the switchboard and the choice of appliances upon it should, therefore, be such as to lessen as much as possible this liability and to eliminate all possibilities of disastrous results therefrom. The purpose of this article is to call attention to a piece of apparatus which embodies all of these requirements in a remarkable degree. We refer to the "Dublarm" Type (Double Pole, Double Arm) I-T-E Circuit Breaker. This type of instrument effectively replaces at the same time the usual circuit breaker and hand switch, combining the functions of both in one self-contained piece of apparatus. The employment of the I-T-E "Dublarm" Circuit Breaker not only contributes to economy of construction and the simplicity of the switchboard, but insures to the generators and circuits with which it is connected absolute protection from

overload, regardless of the manner in which the switchboard appliances may be handled, for the circuit of which this piece of apparatus forms a part cannot, under any conditions, be closed when excessive current would result therefrom. In this respect it possesses obvious advantages over the usual arrangement of independent switch and circuit breaker.

It often happens, in closing a circuit after it has been interrupted by the action of a circuit breaker, that the short-circuit or overload condition has not been removed; under such circumstances the closing of the circuit by means of the circuit breaker, coincident with failure to open the hand switch, may occasion serious injury either to the apparatus or to the operator, inasmuch as the handle being in the grasp of the operator, the opening of the circuit breaker would be retarded to such an extent as to cause arcing, which would be serious in case a heavy current were flowing, and in the event of a dead short-circuit might wreck the generator, or even disable an entire station. Such accidents have been not uncommon in the past, but are rendered impossible by the employment of the "Dublarm" I-T-E Circuit Breaker; for in this instrument both of the poles, in addition to being capable of individual operation, are independently controlled by the same tripping mechanism. When one pole of the circuit breaker is closed it is ready for operation the instant it is subjected to an overload; therefore, should the operator close the other pole while the short-circuit or overload condition still maintains, the pole first closed is instantly released and all damage prevented; under ordinary conditions both sides of the circuit breaker open simultaneously in the event of overload

The "Dublarm" type is also peculiarly adapted to the protection of motors, whose management is likely to be in the hands of those whose knowledge of electricity is not ordinarily such as to insure proper handling of the apparatus in their charge; but with each motor protected by a "Dublarm" I-T-E Circuit Breaker, the possibility of damage from overload is completely eliminated.

The essential feature of the Double Pole, Double Arm Circuit Breaker, whether single or double coil, is that the same tripping mechanism engages at the same time with BOTH of the retaining catches; thus simultaneous opening of the two poles is insured. One way this is accomplished in the "Dublarm" is shown below.



Recognizing the need for circuit breakers of the "Dublarm" type for all classes of work, we are prepared to furnish them in all capacities and to meet all conditions. We make them from 5 to 7,500 amperes, for Overload, No Voltage, Overload and No Voltage, Reversal, and Overload and Reversal, each the best that brains and skill can produce, and each the embodiment of simplicity, adaptability and efficiency.

DIMENSIONAL DIAGRAMS OF I-T-E CIRCUIT BREAKERS

In order that engineers may readily inform themselves as to the dimensions of our standard types of Circuit Breakers, we give herewith outline drawings of types and sizes most in demand. On account of the immense variety of instruments made by us, it is manifestly impossible to give data covering the entire scope of our product. To engineers requiring special information we will be glad to send, upon receipt of specifications, whatever further data may be necessary.

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T. A. BIBBER & CO.,
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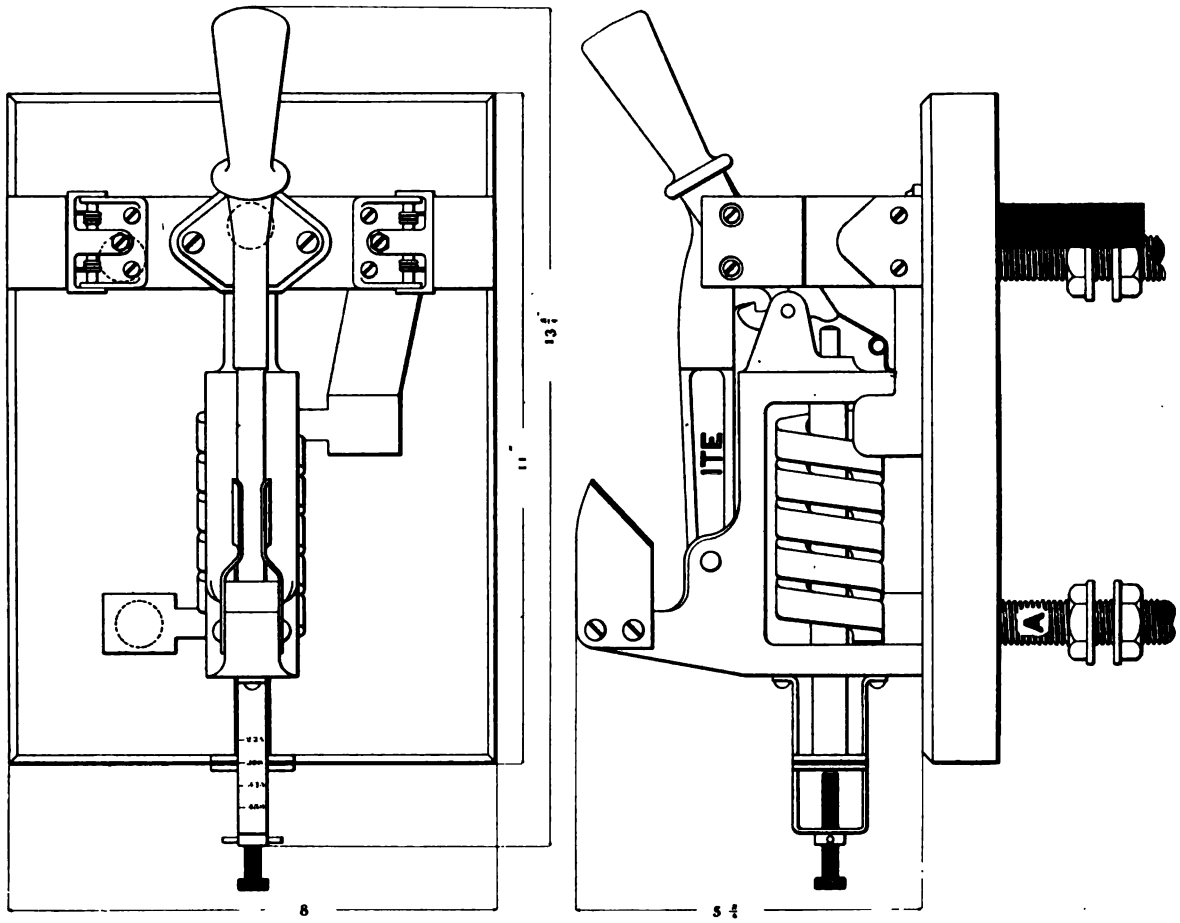


I-T-E CIRCUIT BREAKER

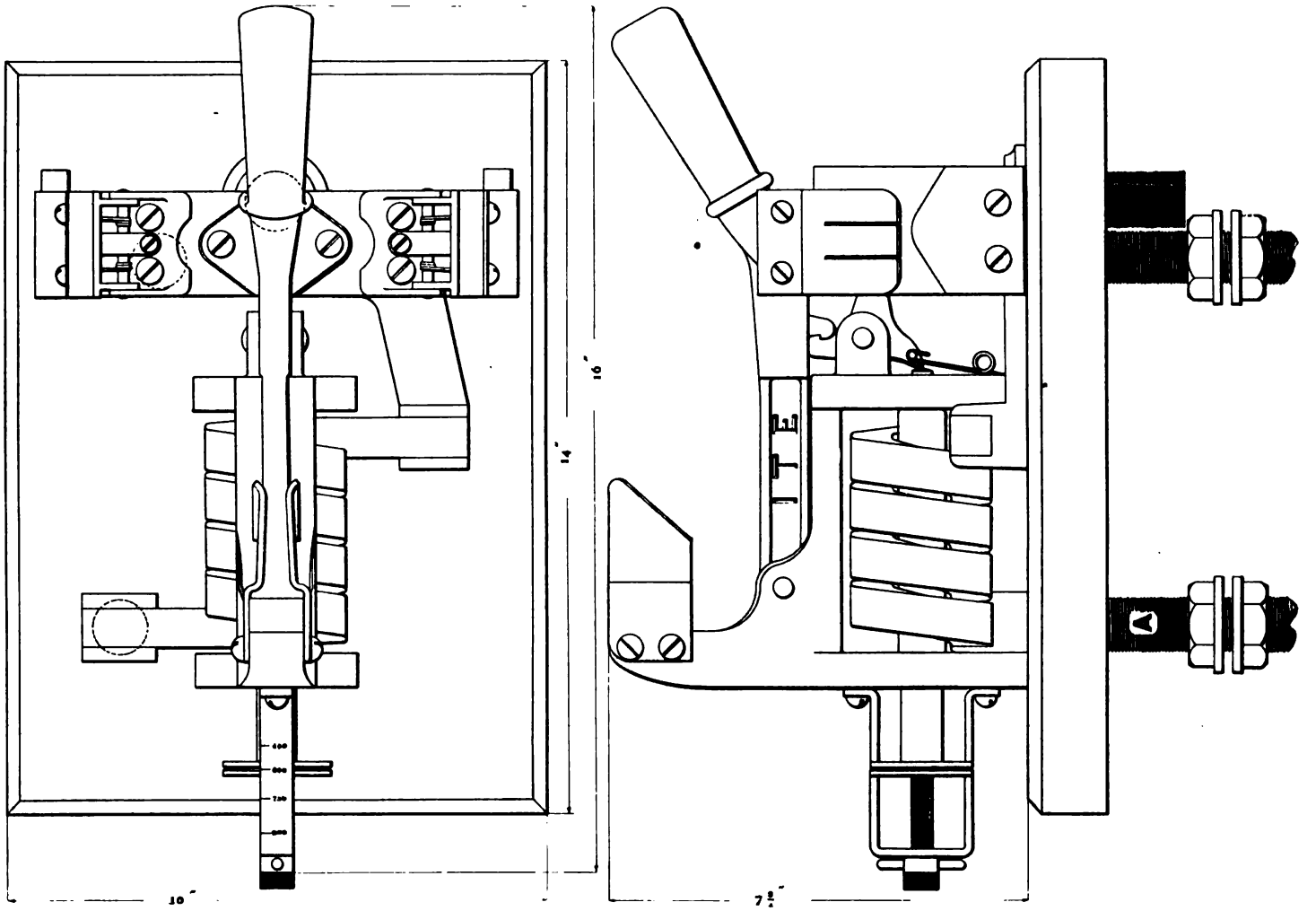
SINGLE POLE

MIDGET SENIOR TYPE

See Pages 12 and 13, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
300	3/4″	**100**	1/2″
200	5/8″	**80** and under	3/8″
150	1/2″		



I-T-E CIRCUIT BREAKER

SINGLE POLE

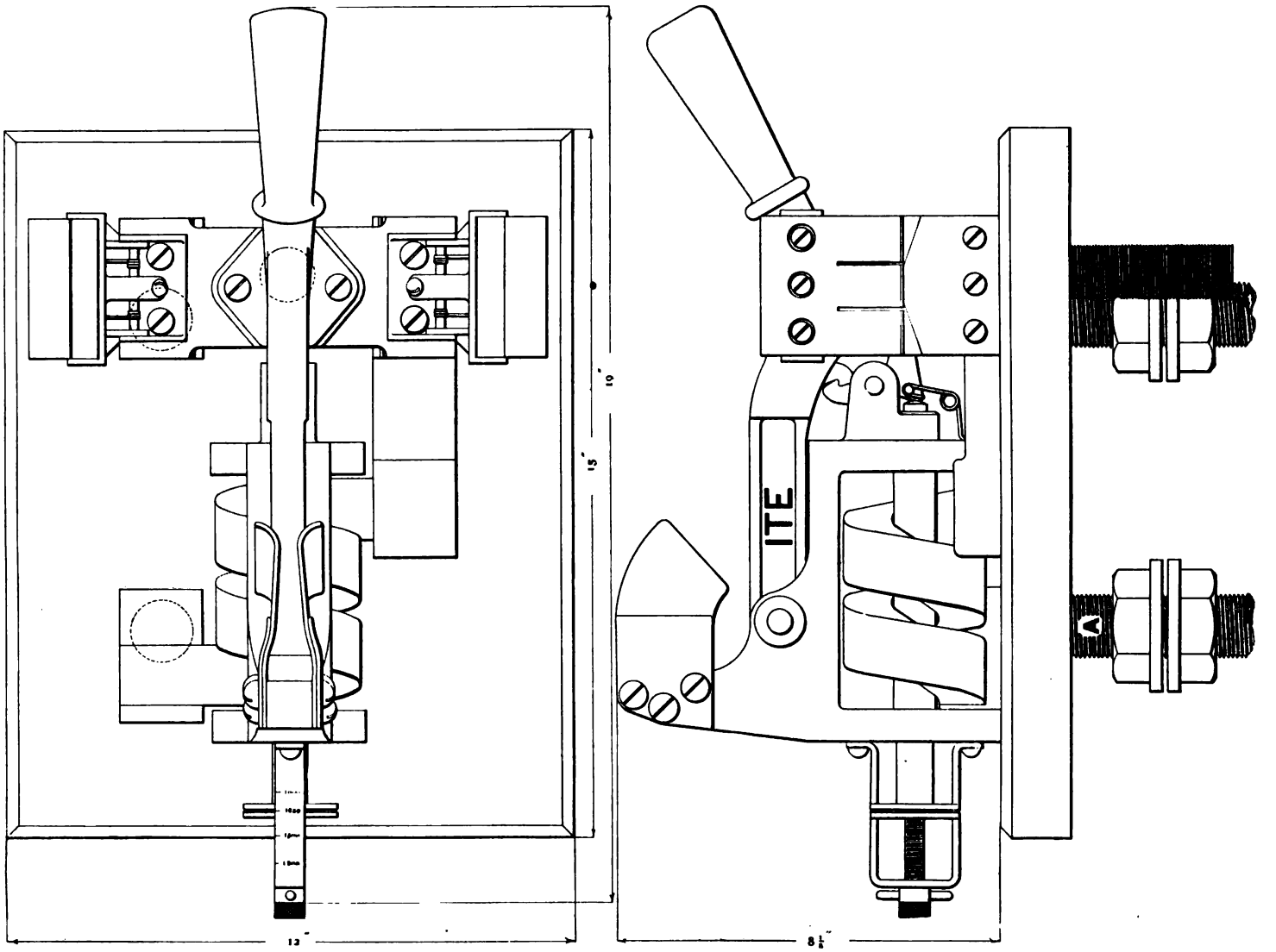
STANDARD SWITCHBOARD TYPE

700 Amperes and under

See Pages 16 and 17, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
700	1″	**400**	7/8″
600	1″	**300**	3/4″
500	7/8″	**200** and under	5/8″



I-T-E CIRCUIT BREAKER

SINGLE POLE

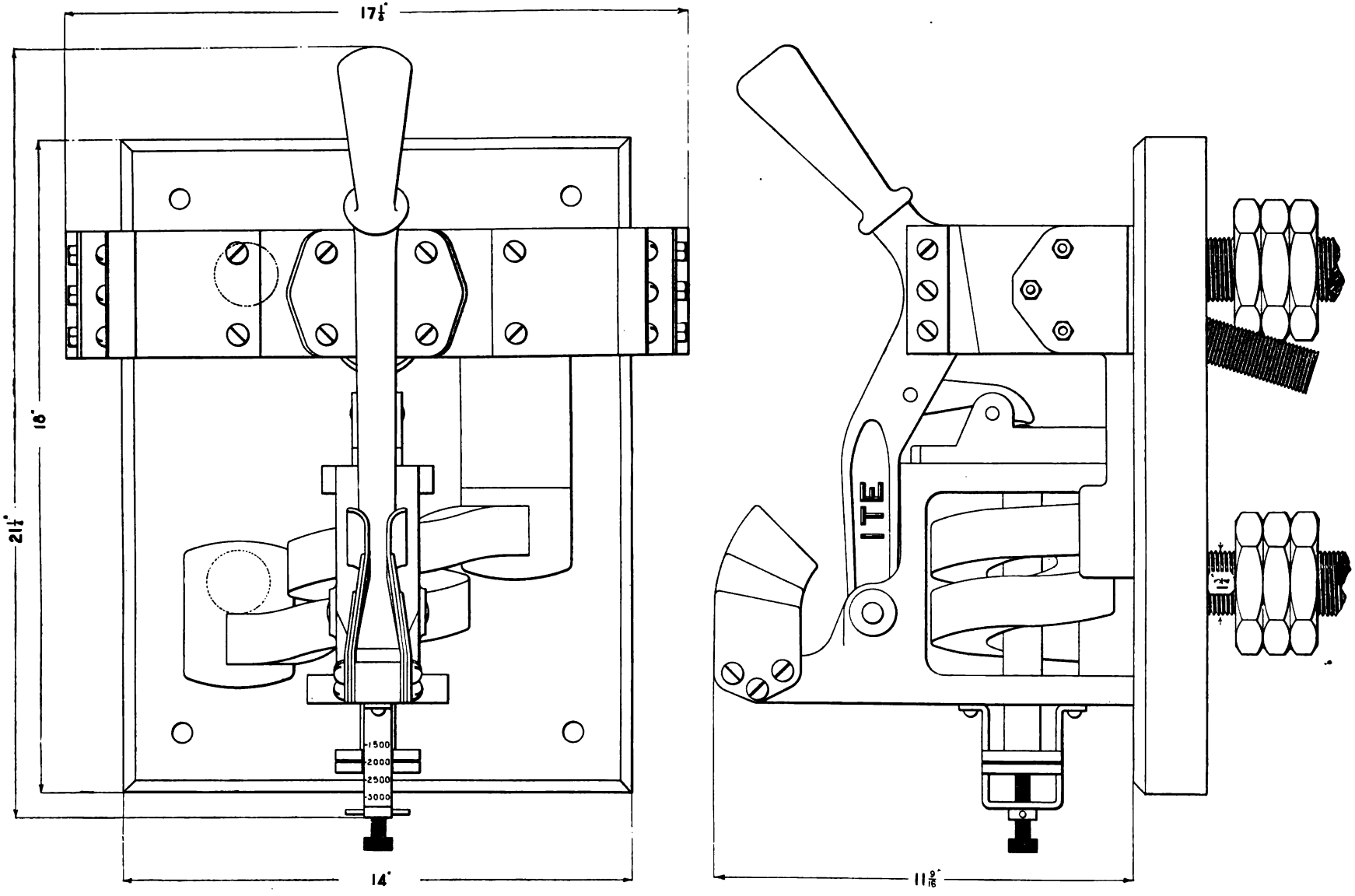
STANDARD SWITCHBOARD TYPE

800 to 1500 Amperes

See Pages 16 and 17, Catalogue, July 1, 1901

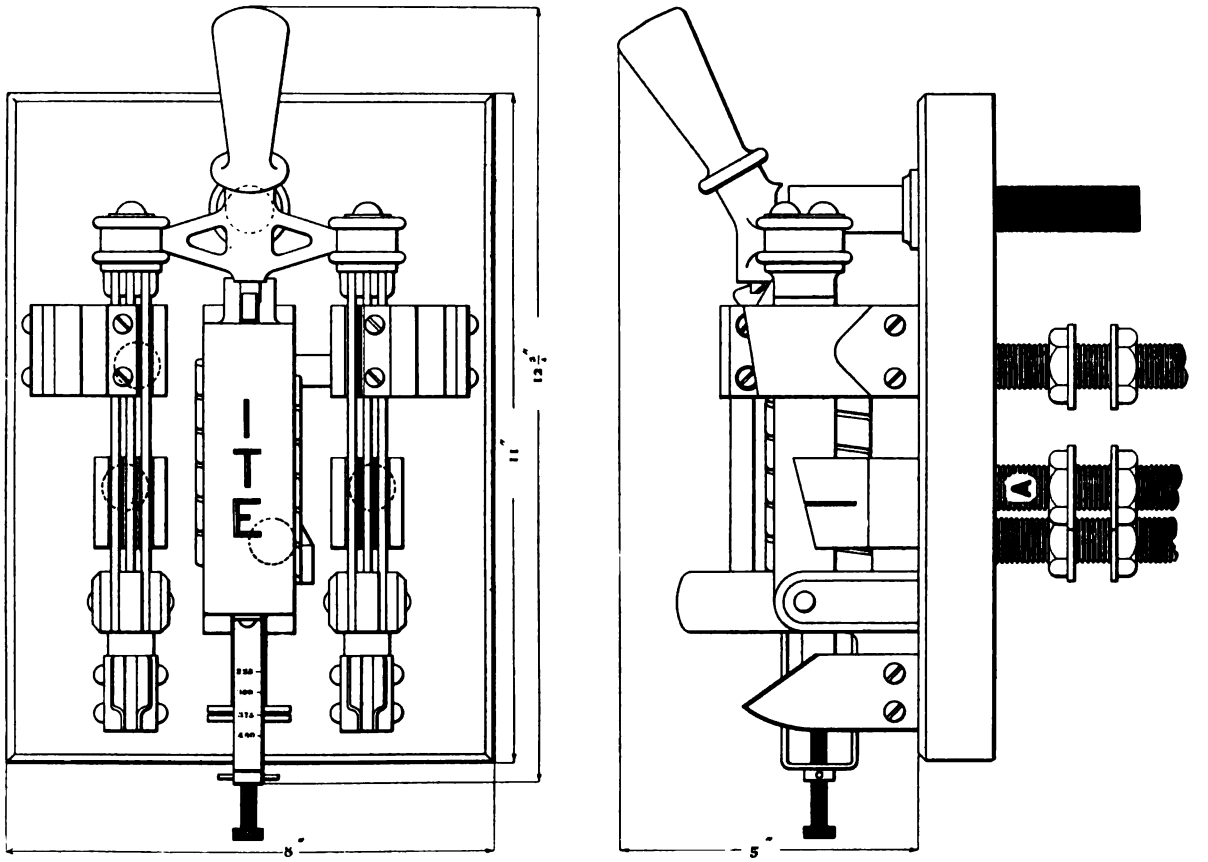
DIAMETER OF STUDS "A"

Amps.		Amps.	
1500	**1 1/2″**	**1000**	**1 1/4″**
1250	**1 3/8″**	**800**	**1 1/8″**



I-T-E CIRCUIT BREAKER

SINGLE POLE
STANDARD SWITCHBOARD TYPE
2000 Amps. Capacity
To be superseded by later design



I-T-E CIRCUIT BREAKER

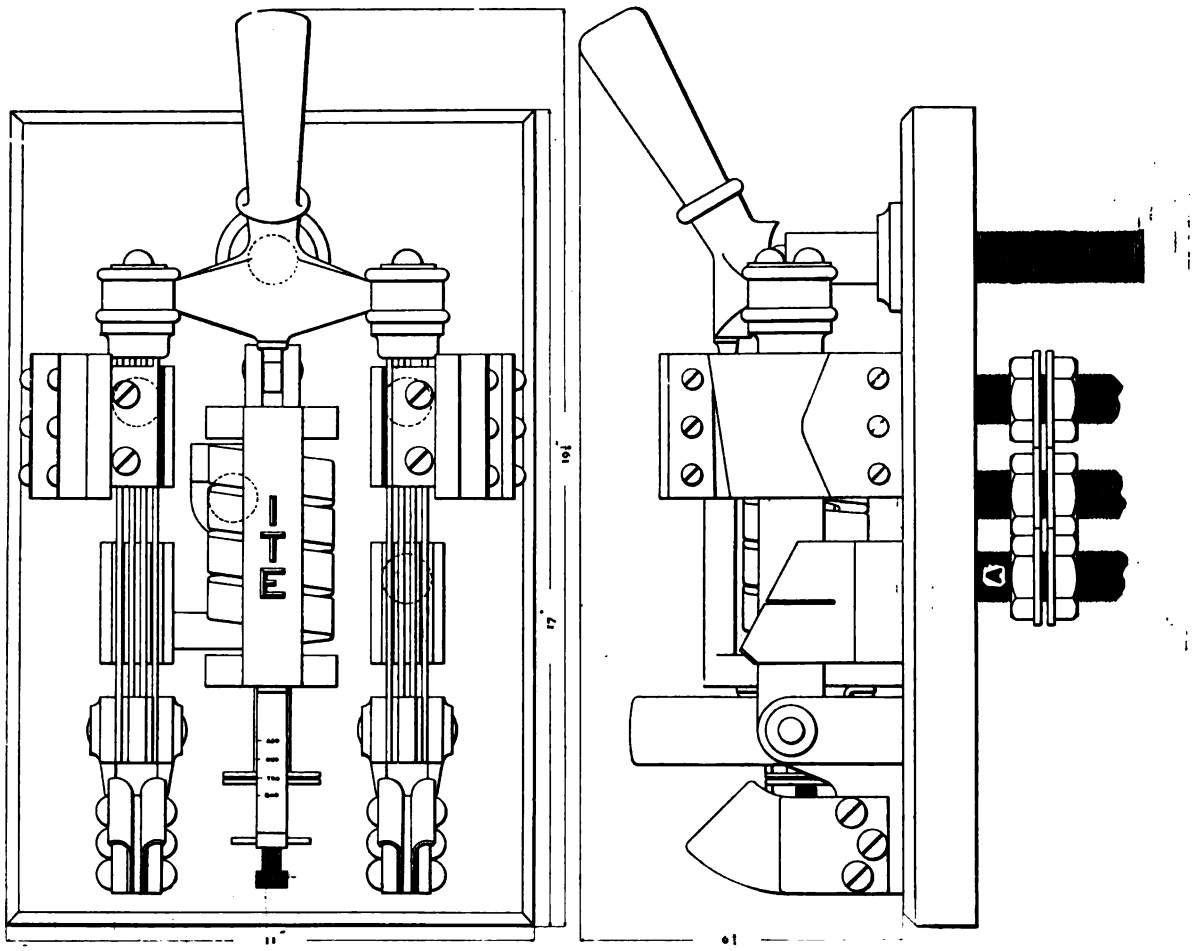
DOUBLE POLE

MIDGET SENIOR TYPE

See Pages 26 and 27, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
300	**3/4″**	**100**	**1/2″**
200	**5/8″**	**80** and under	**3/8″**
150	**1/2″**		



I-T-E CIRCUIT BREAKER

DOUBLE POLE

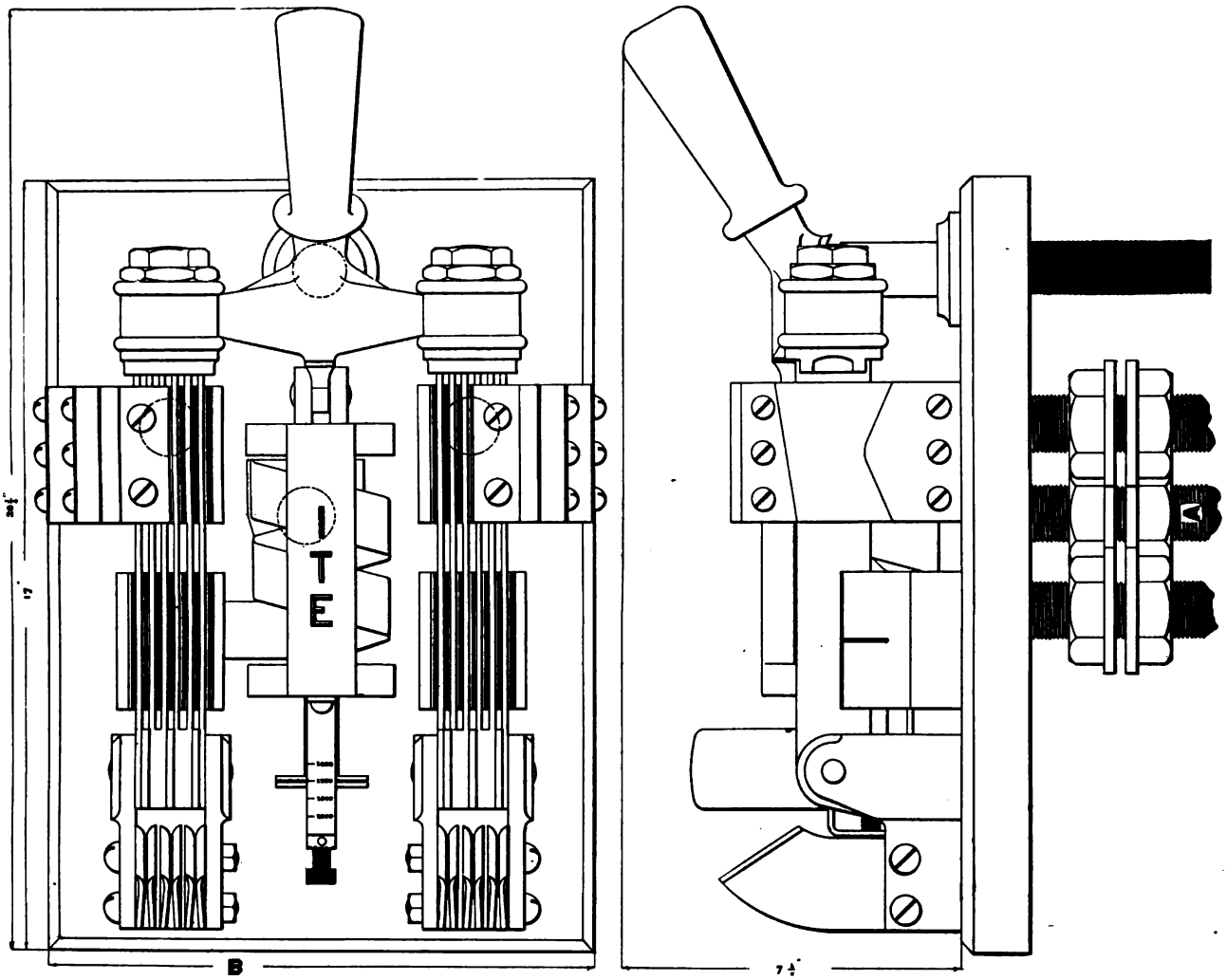
STANDARD SWITCHBOARD TYPE

600 Amperes and under

See Pages 30 and 31, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
600	1″	**300**	3/4″
500	7/8″	**200** and under	5/8″
400	7/8″		



I-T-E CIRCUIT BREAKER

DOUBLE POLE

STANDARD SWITCHBOARD TYPE

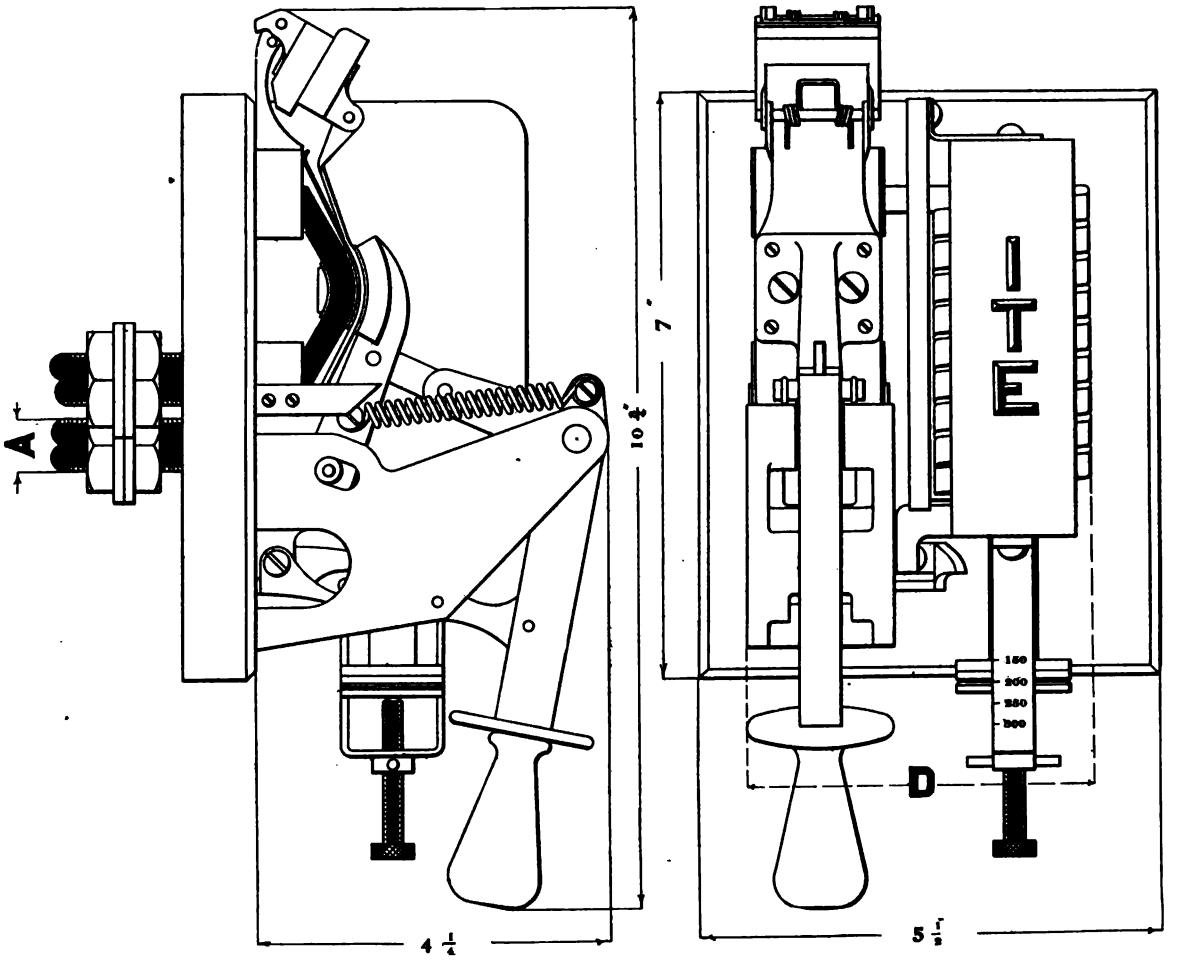
800 to 1250 Amperes

See Pages 30 and 31, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	B	Amps.	A	B
1250	**1 3/8″**	**12″**	**800**	**1 1/8″**	**11″**
1000	**1 1/4″**	**11″**			

To be superseded by later design



I-T-E LAMINATED CIRCUIT BREAKER

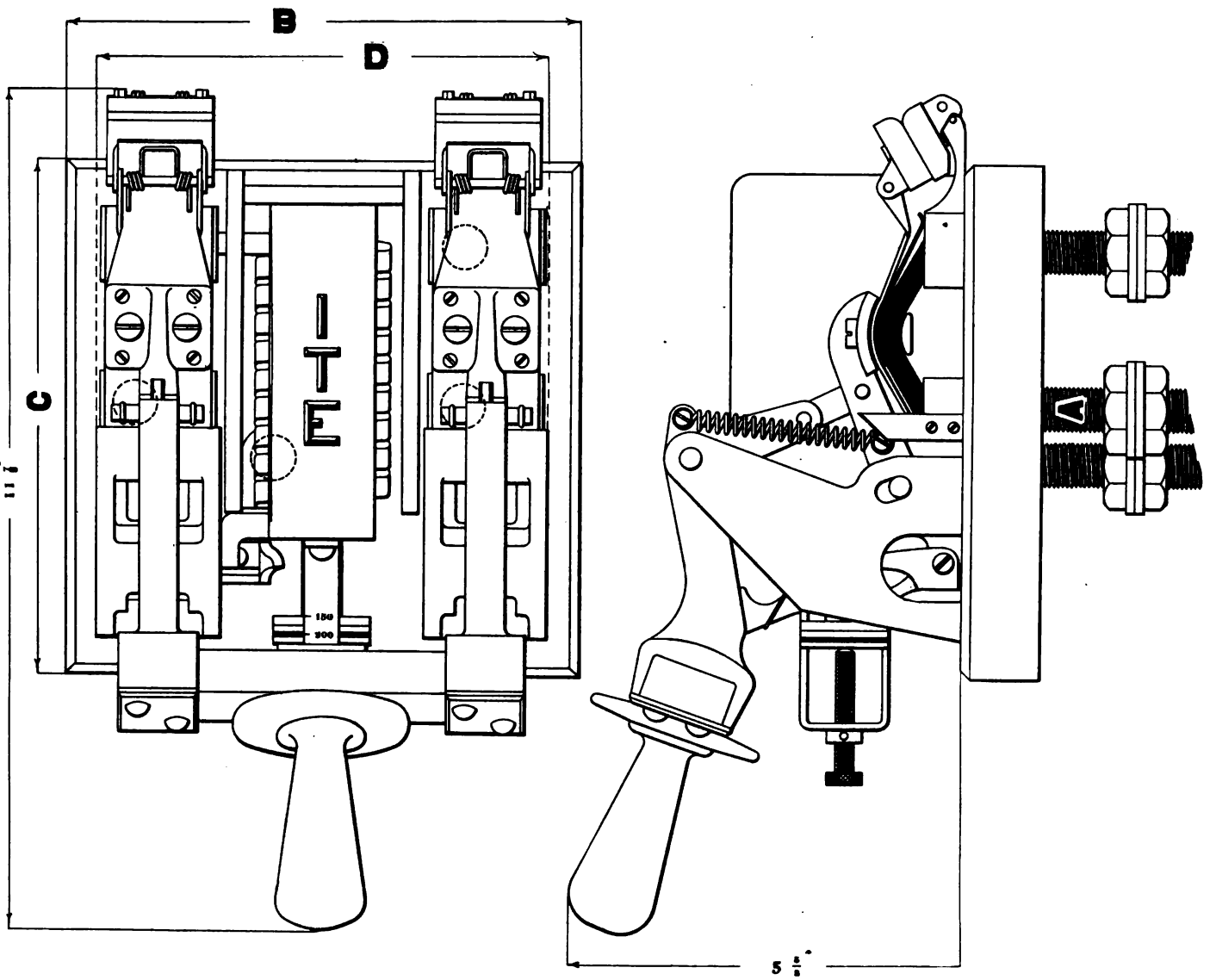
OVERLOAD—SINGLE POLE

"E-L" TYPE

See Pages 116 and 117, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	D	Amps.	A	D
300	3/4"	4 7/16"	100	1/2"	4 1/8"
200	5/8"	4 1/8"	80 and under	3/8"	4 1/8"
150	1/2"	4 1/8"			



I-T-E LAMINATED CIRCUIT BREAKER

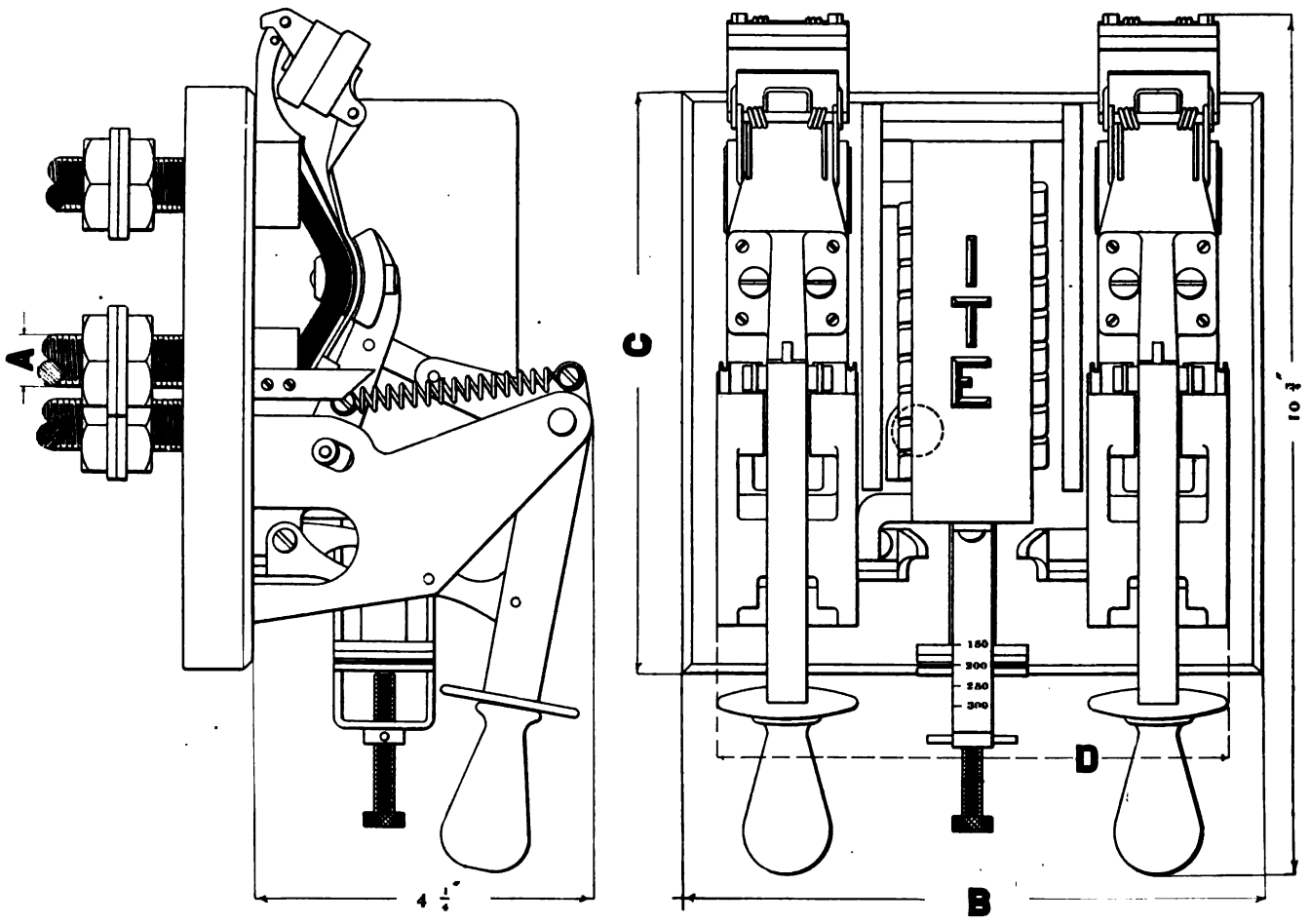
OVERLOAD—DOUBLE POLE

"F-L" TYPE

See Pages 118 and 119, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	B	C	D
300	3/4"	8"	8"	7"
200	5/8"	7 1/4"	7 1/4"	6 3/8"
150	1/2"	7 1/4"	7 1/4"	6 3/8"
100	1/2"	7 1/4"	7 1/4"	6 3/8"
80 and under	3/8"	7 1/4"	7 1/4"	6 3/8"



I-T-E LAMINATED CIRCUIT BREAKER

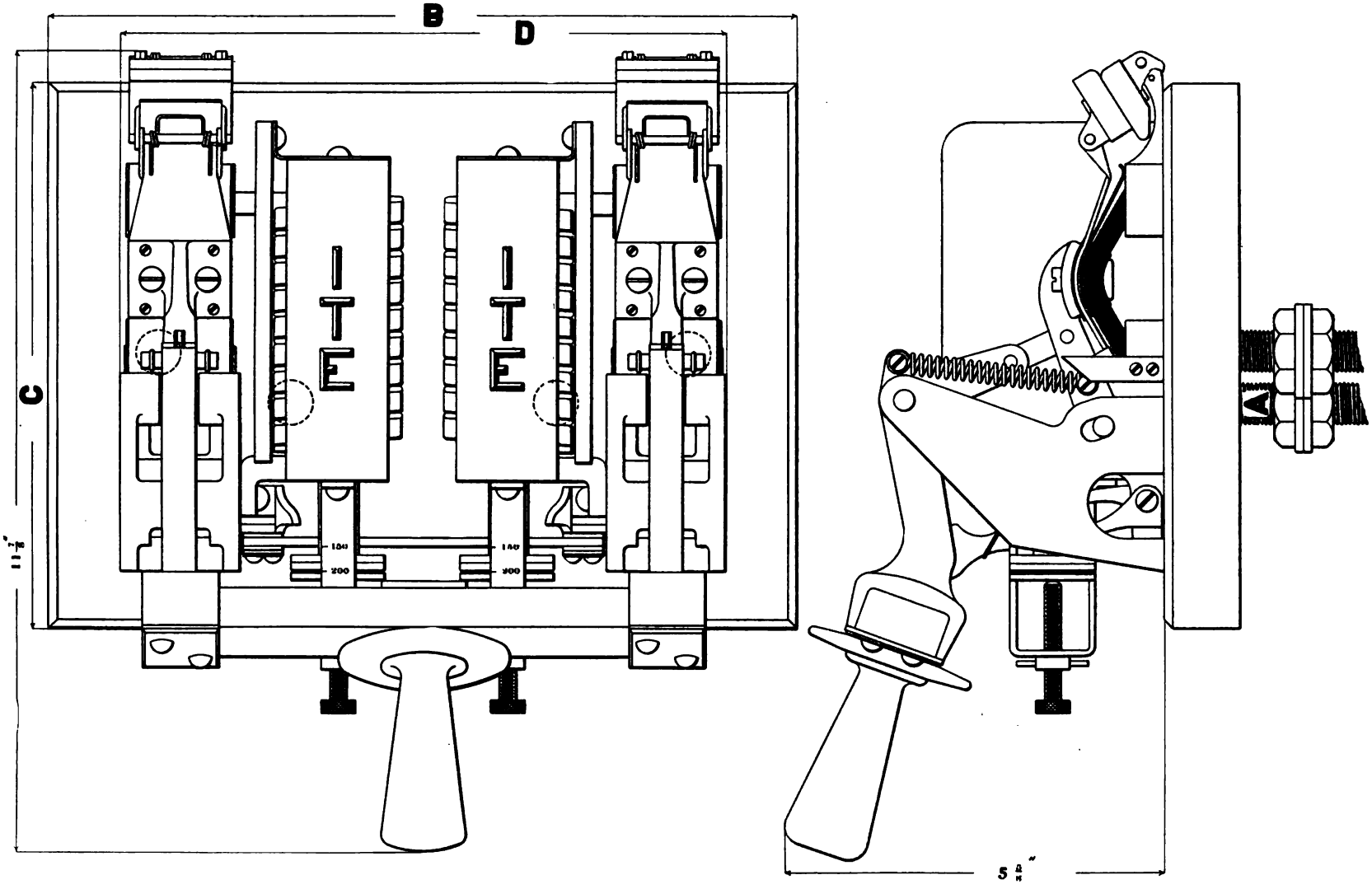
OVERLOAD—DOUBLE POLE

"I-L" TYPE

See Pages 120 and 121, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	B	C	D
300	3/4"	8"	8"	7"
200	5/8"	7 1/4"	7 1/4"	6 3/8"
150	1/2"	7 1/4"	7 1/4"	6 3/8"
100	1/2"	7 1/4"	7 1/4"	6 3/8"
80 and under,	3/8"	7 1/4"	7 1/4"	6 3/8"



I-T-E LAMINATED CIRCUIT BREAKER

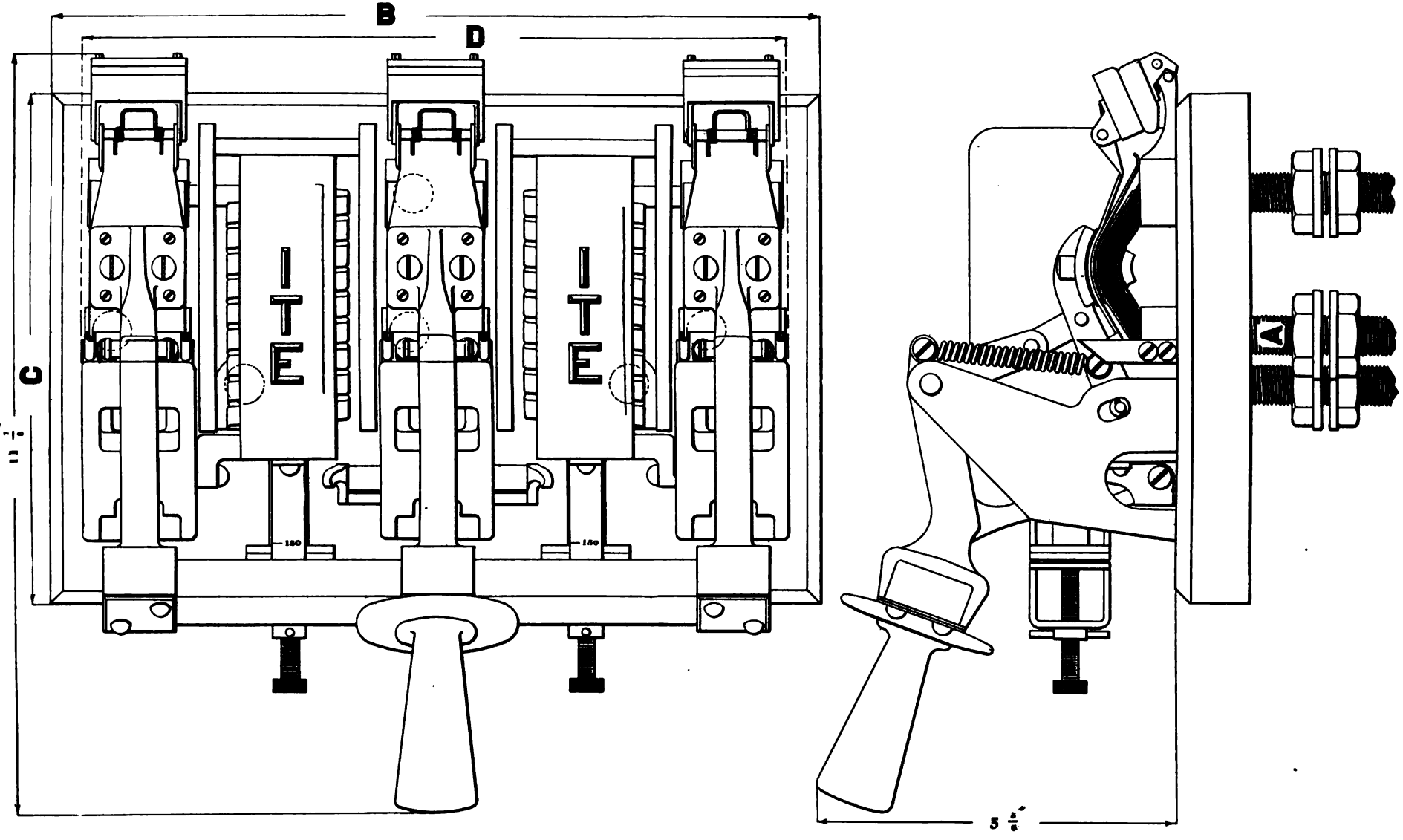
OVERLOAD—DOUBLE POLE
DOUBLE COIL. "B-L" TYPE

See Pages 122 and 123, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	B	C	D
300	3/4″	11″	8″	9 1/2″
200	5/8″	11″	8″	8 7/8″
150	1/2″	11″	8″	8 7/8″

Amps.	A	B	C	D
100	1/2″	11″	8″	8 7/8″
80 and under	3/8″	11″	8″	8 7/8″



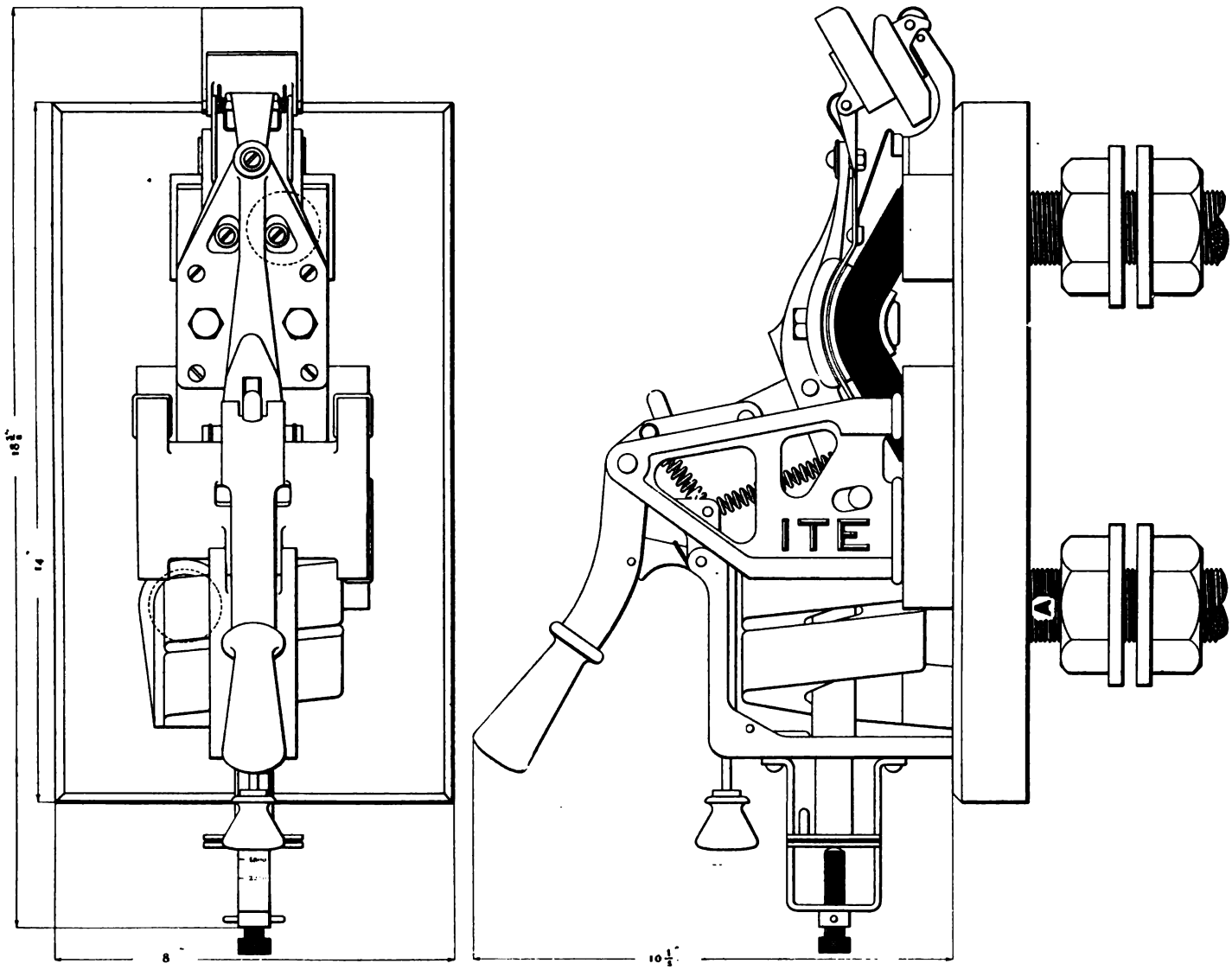
I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—TRIPLE POLE
DOUBLE COIL. "J-L" TYPE

See Pages 124 and 125, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.	A	B	C	D	Amps.	A	B	C	D
300	3/4″	13″	9″	12 1/4″	100	1/2″	12″	8″	11″
200	5/8″	12″	8″	11″	80 and under,	3/8″	12″	8″	11″
150	1/2″	12″	8″	11″					



I-T-E LAMINATED CIRCUIT BREAKER

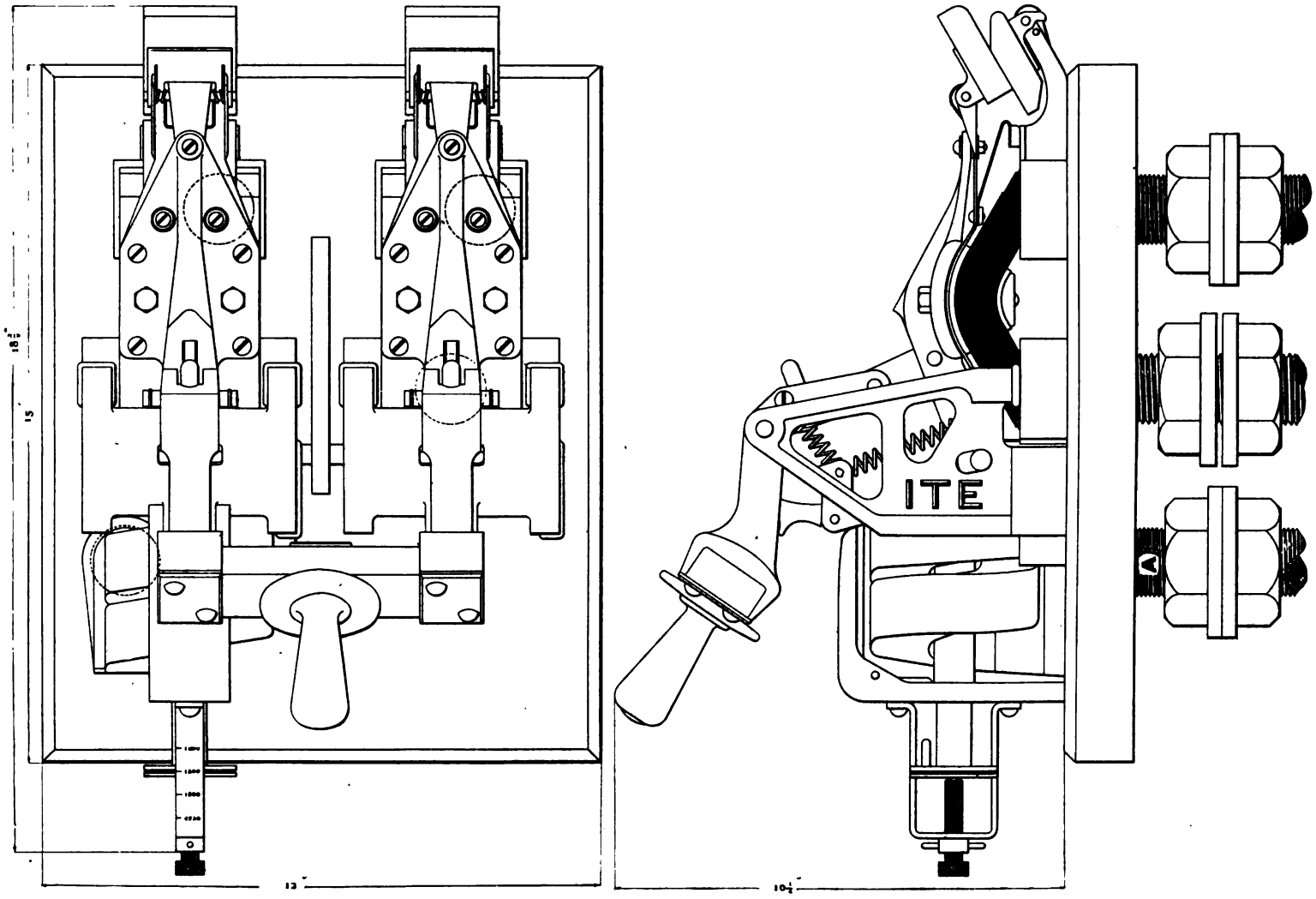
OVERLOAD—SINGLE POLE

"N-L" TYPE

See Pages 126 and 127, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
1500	**1 1/2″**	**500**	**7/8″**
1250	**1 3/8″**	**400**	**7/8″**
1000	**1 1/4″**	**300**	**3/4″**
800	**1 1/8″**	**200** and under	**5/8″**
600	**1″**		



I-T-E LAMINATED CIRCUIT BREAKER

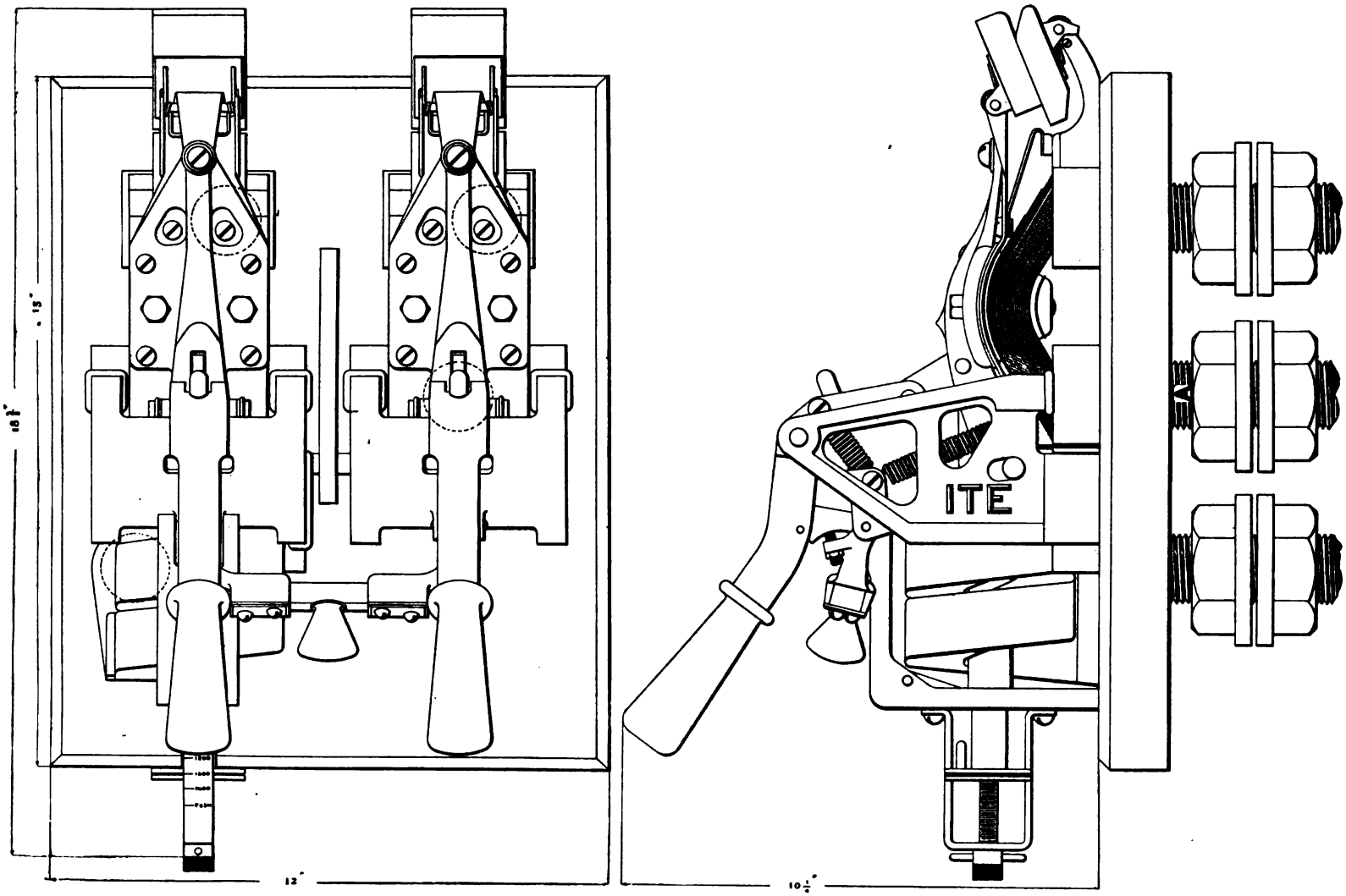
OVERLOAD—DOUBLE POLE

"O-L" TYPE

See Pages 128 and 129, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
1500	1 1/2″	500	7/8″
1250	1 3/8″	400	7/8″
1000	1 1/4″	300	3/4″
800	1 1/8″	200 and under	5/8″
600	1″		



I-T E LAMINATED CIRCUIT BREAKER

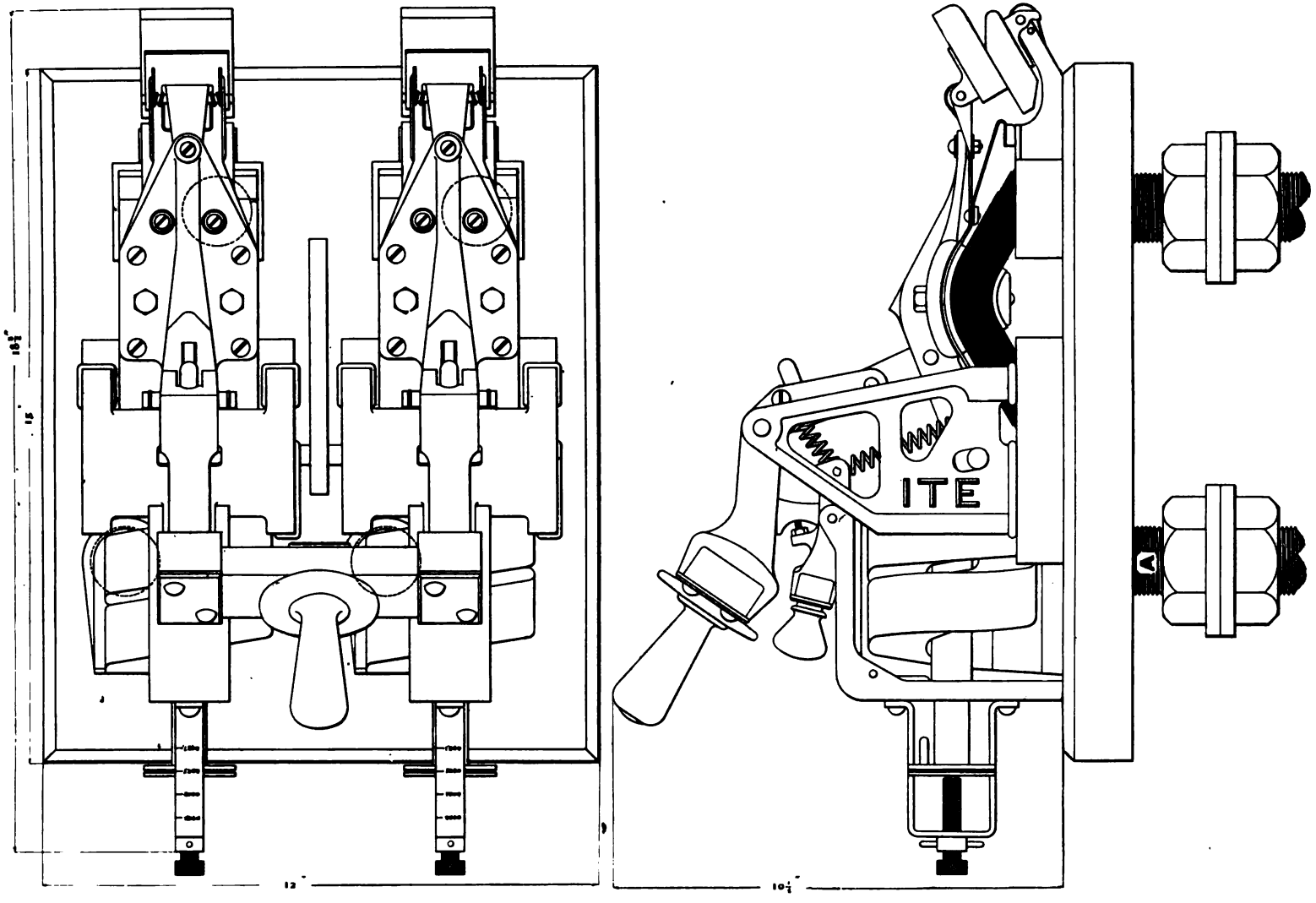
OVERLOAD—DOUBLE POLE

"P-L" TYPE

See Pages 132 and 133, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
1500	1 1/2″	500	7/8″
1250	1 3/8″	400	7/8″
1000	1 1/4″	300	3/4″
800	1 1/8″	200 and under	5/8″
600	1″		



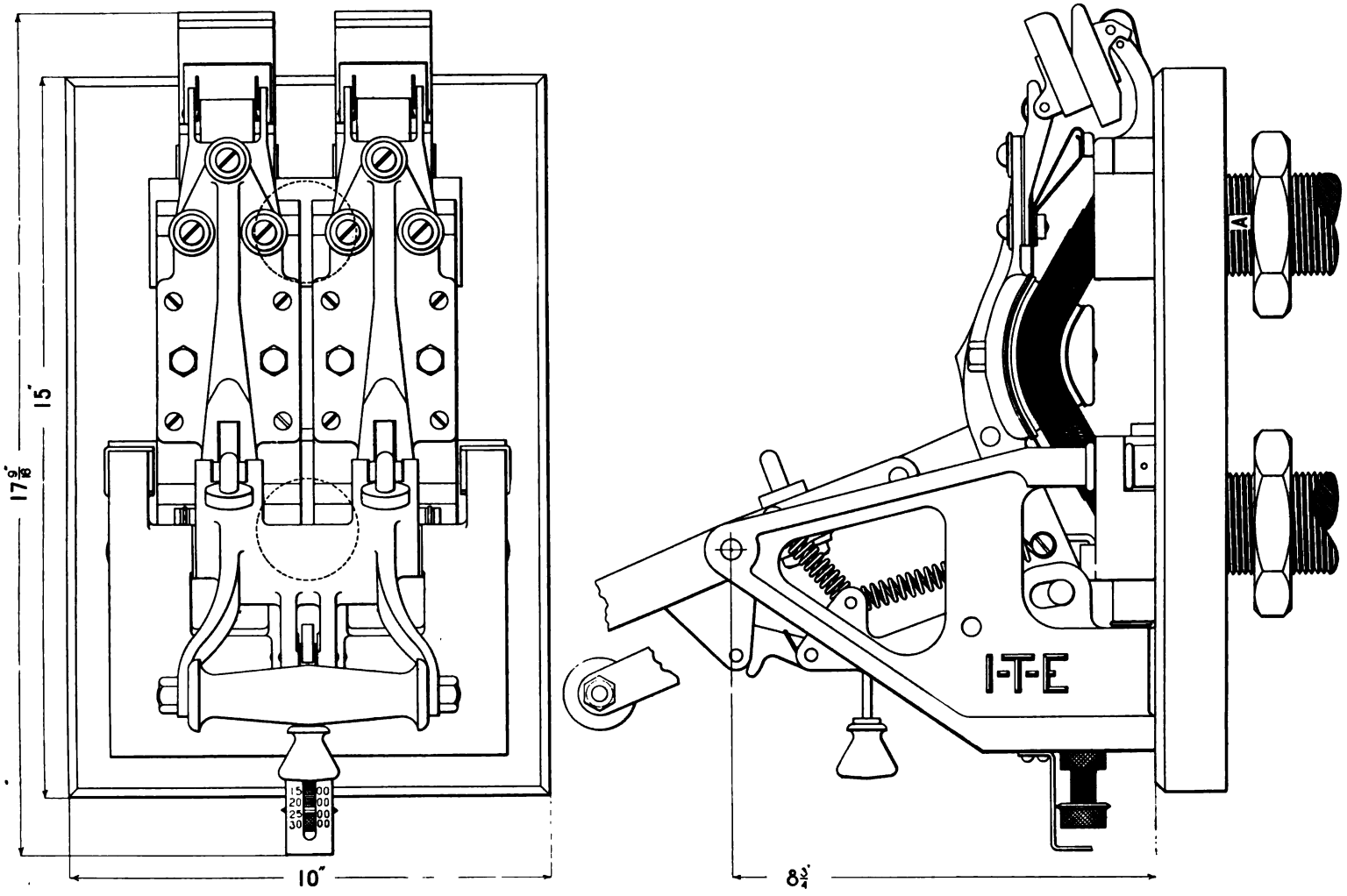
I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—DOUBLE POLE
DOUBLE COIL. "Q-L" TYPE

See Pages 136 and 137, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		Amps.	
1500	1 1/2″	500	7/8″
1250	1 3/8″	400	7/8″
1000	1 1/4″	300	3/4″
800	1 1/8″	200 and under	5/8″
600	1″		



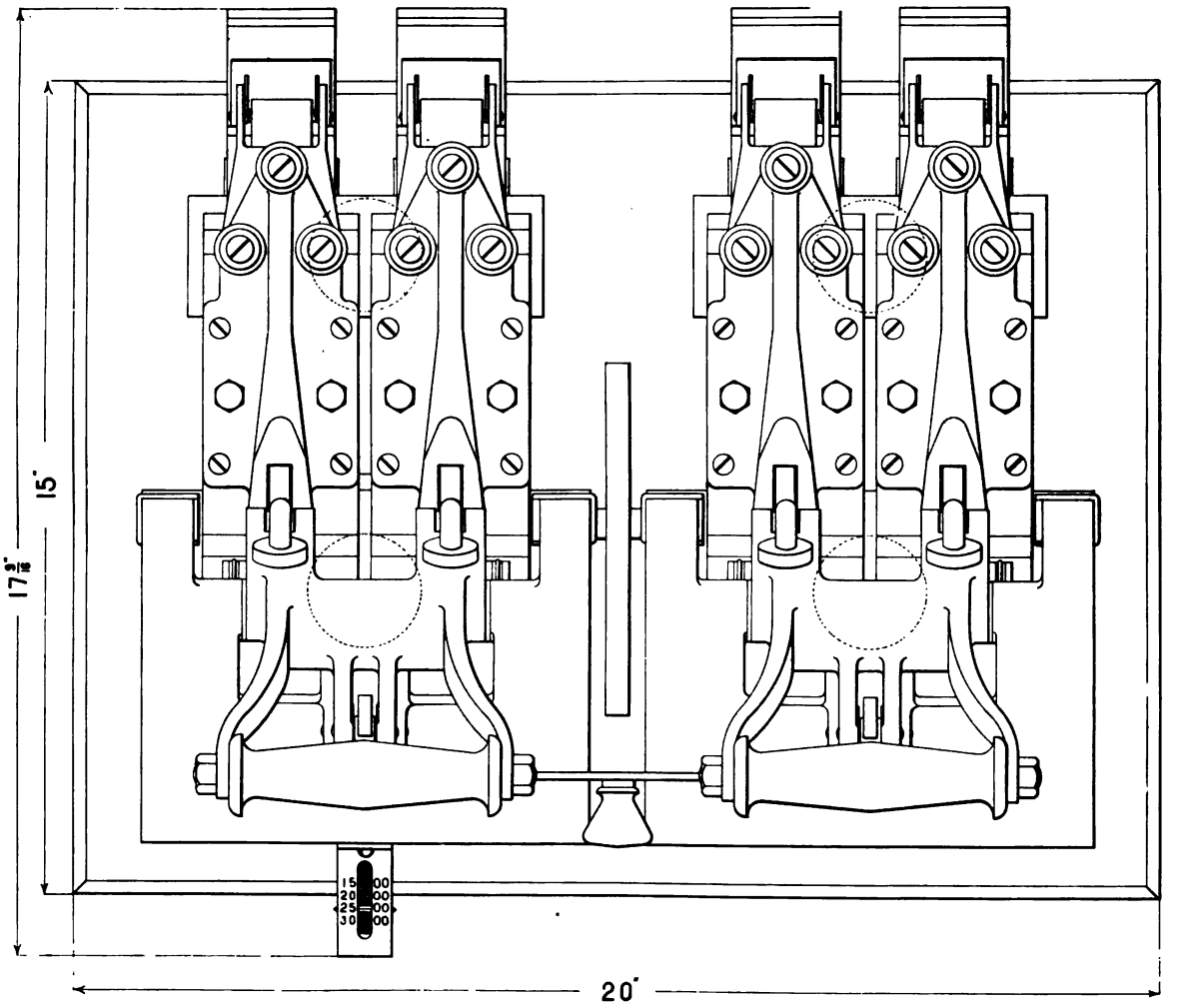
I-T-E CIRCUIT BREAKER

SINGLE POLE

SPECIAL FOR 250 VOLTS (OR LESS) ONLY

DIAMETER OF STUDS "A"

2000 amps. . . . . . **1¾″** **2500 amps.** . . . . . **1⅞″**



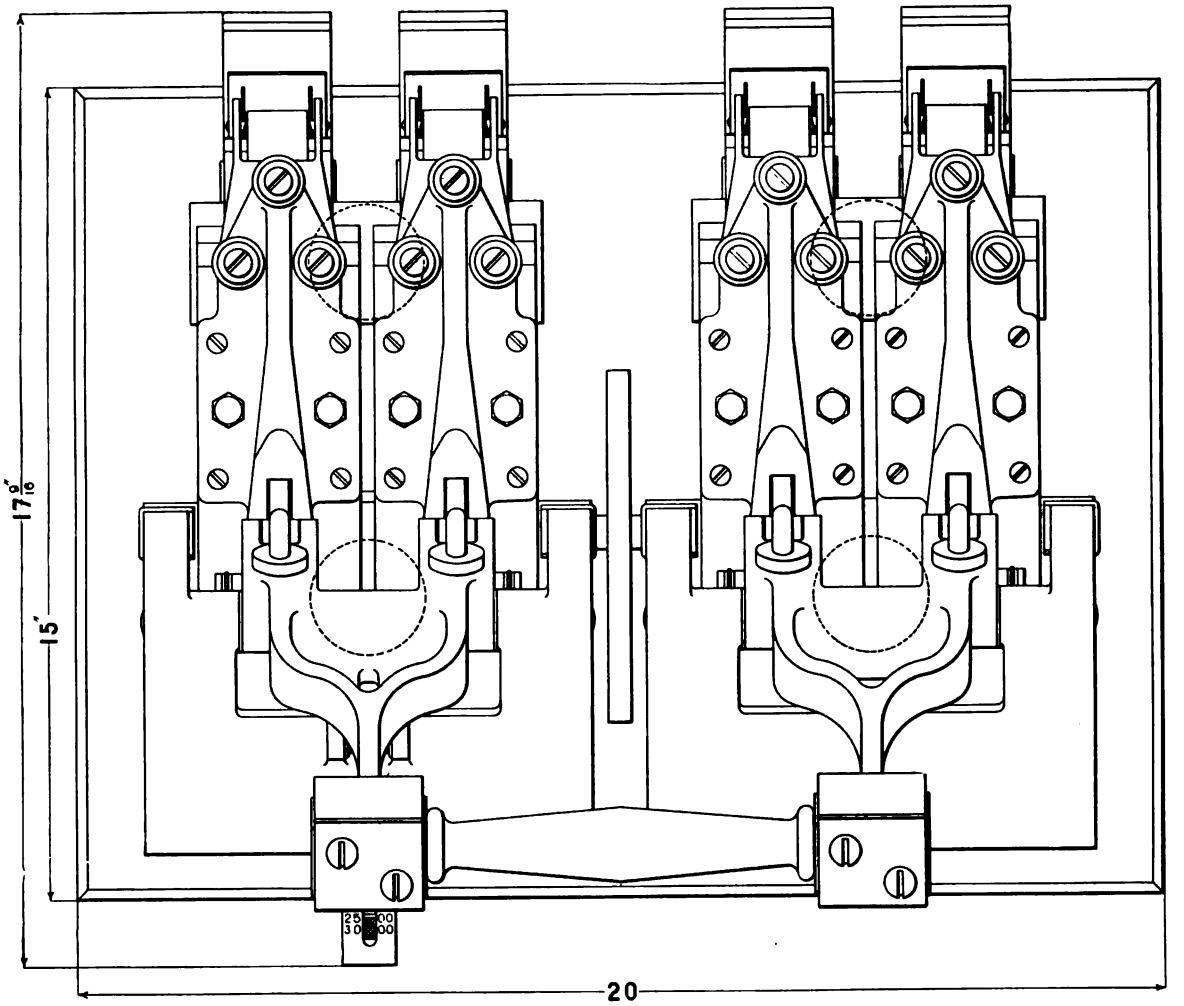
I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—DOUBLE POLE

SPECIAL FOR 250 VOLTS (OR LESS) ONLY

DIAMETER OF STUDS

2000 amps. . . . . . **1¾″** **2500 amps.** . . . . . **1⅞″**



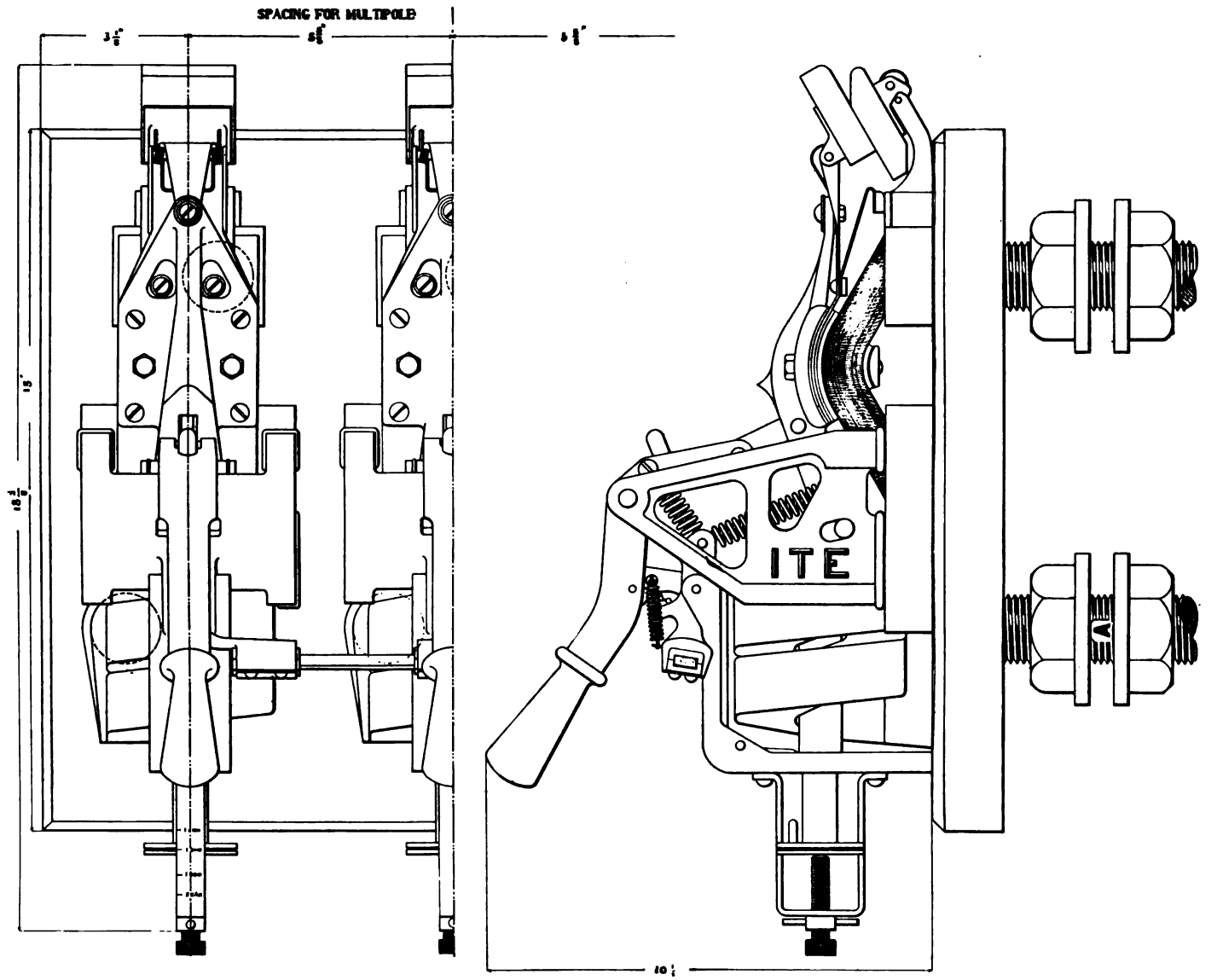
I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—DOUBLE POLE

SPECIAL FOR 250 VOLTS (OR LESS) ONLY

DIAMETER OF STUDS

2000 amps. . . . . . 1¾″ **2500 amps.** . . . . . 1⅞″

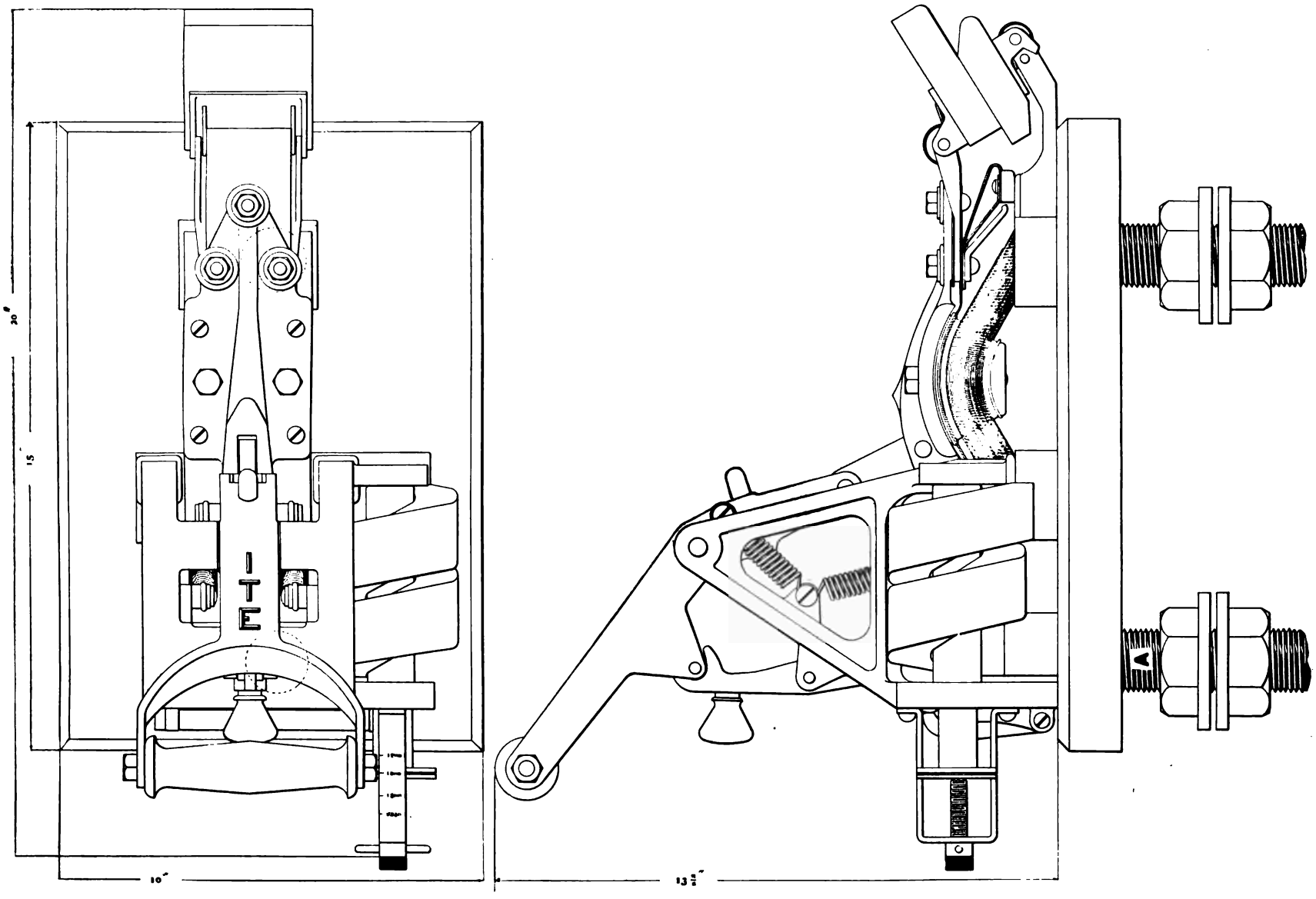


I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—"MULTIPOLAR"

DIAMETER OF STUDS "A"

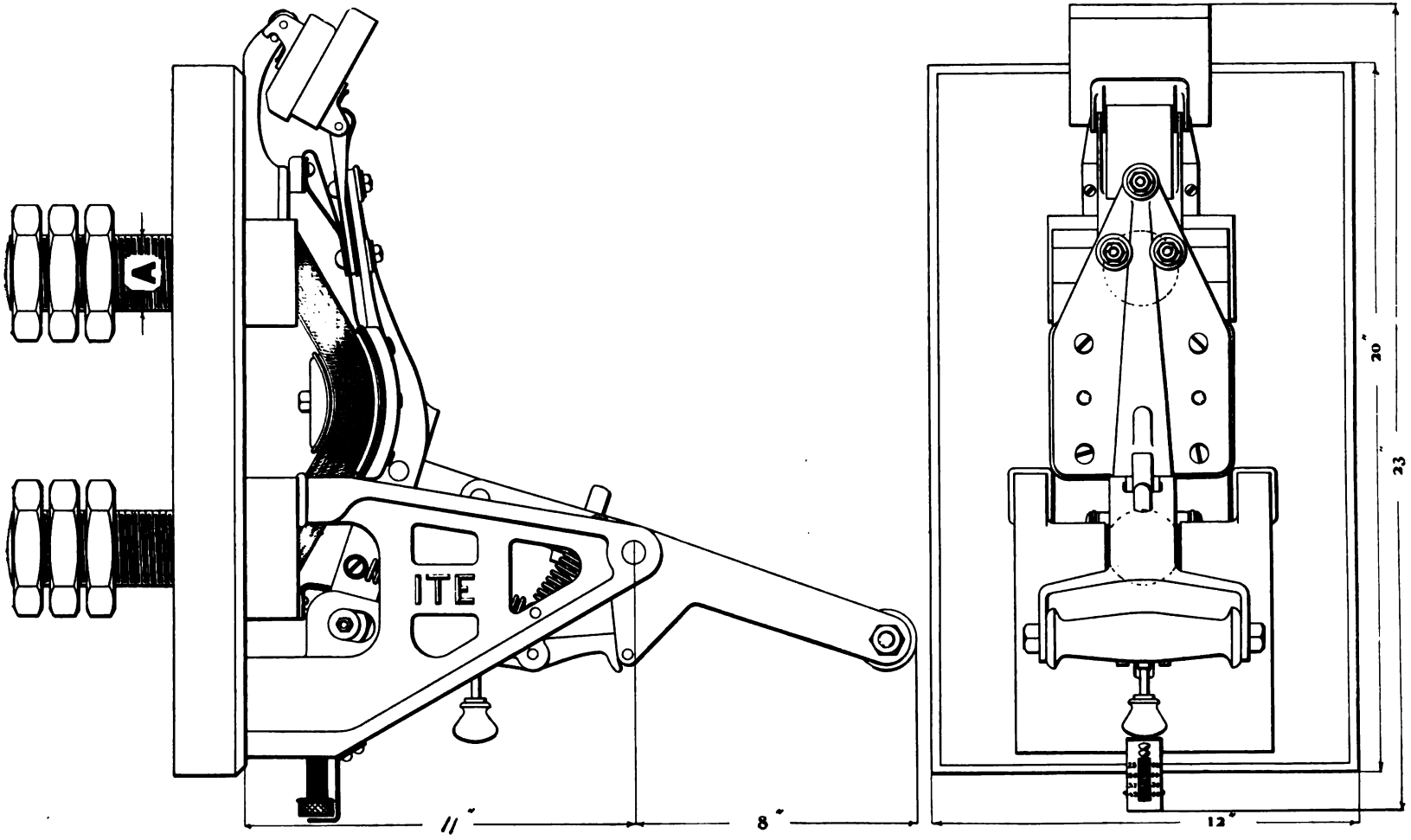
Amps.		Amps.	
1500	1 1/2″	500	7/8″
1250	1 3/8″	400	7/8″
1000	1 1/4″	300	3/4″
800	1 1/8″	200 and under	5/8″
600	1″		



I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—SINGLE POLE
"LAM" TYPE
1500 Amperes and under
See Pages 142 and 143, Catalogue, July 1, 1901
DIAMETER OF STUDS "A"

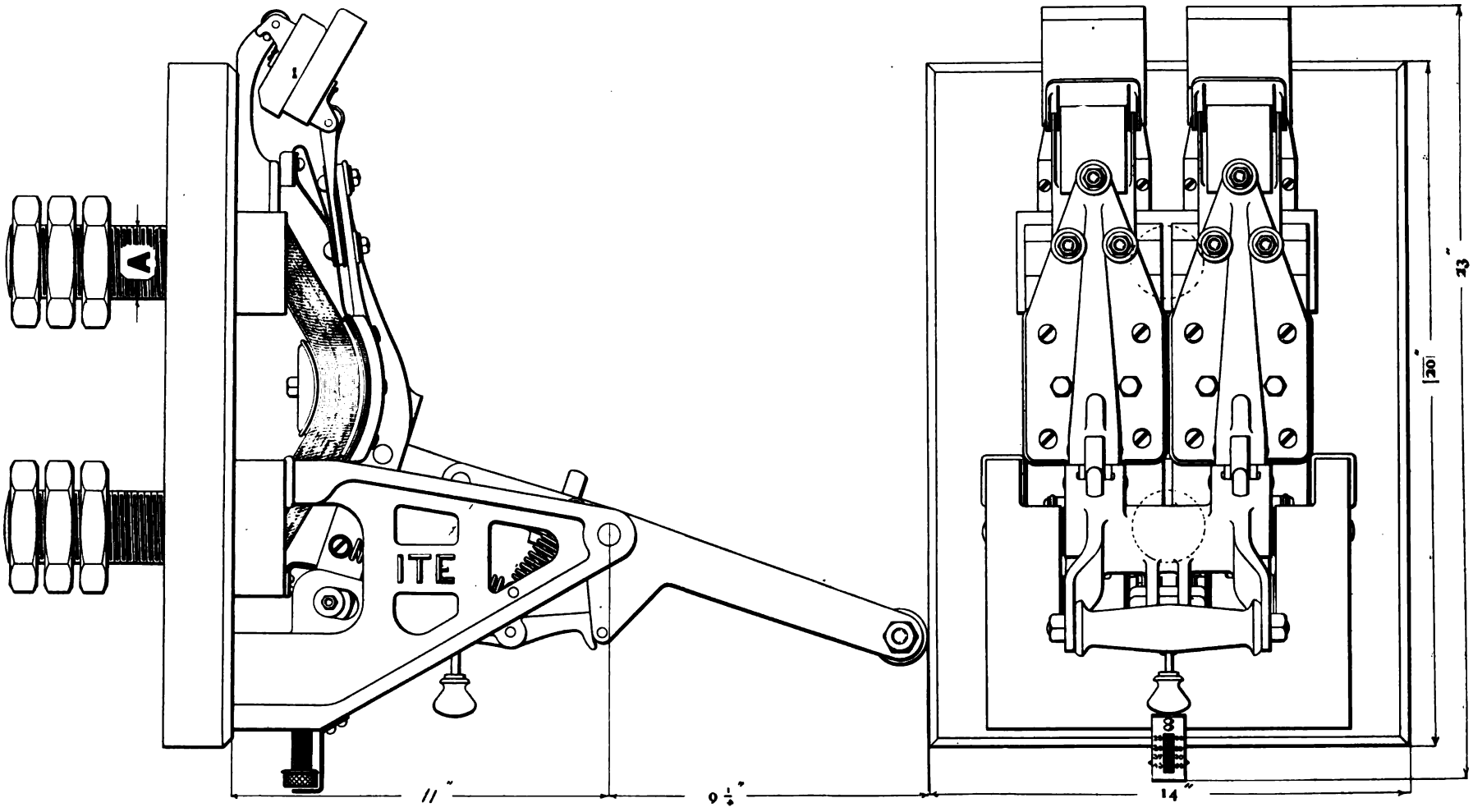
Amps.		Amps.	
1500	1 1/2″	500	7/8″
1250	1 3/8″	400	7/8″
1000	1 1/4″	300	3/4″
800	1 1/8″	200	5/8″
600	1″		



I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—SINGLE POLE
"LAM" TYPE
2000, 2500 and 3000 Amperes
See Page 143, Catalogue, July 1, 1901
DIAMETER OF STUDS "A"

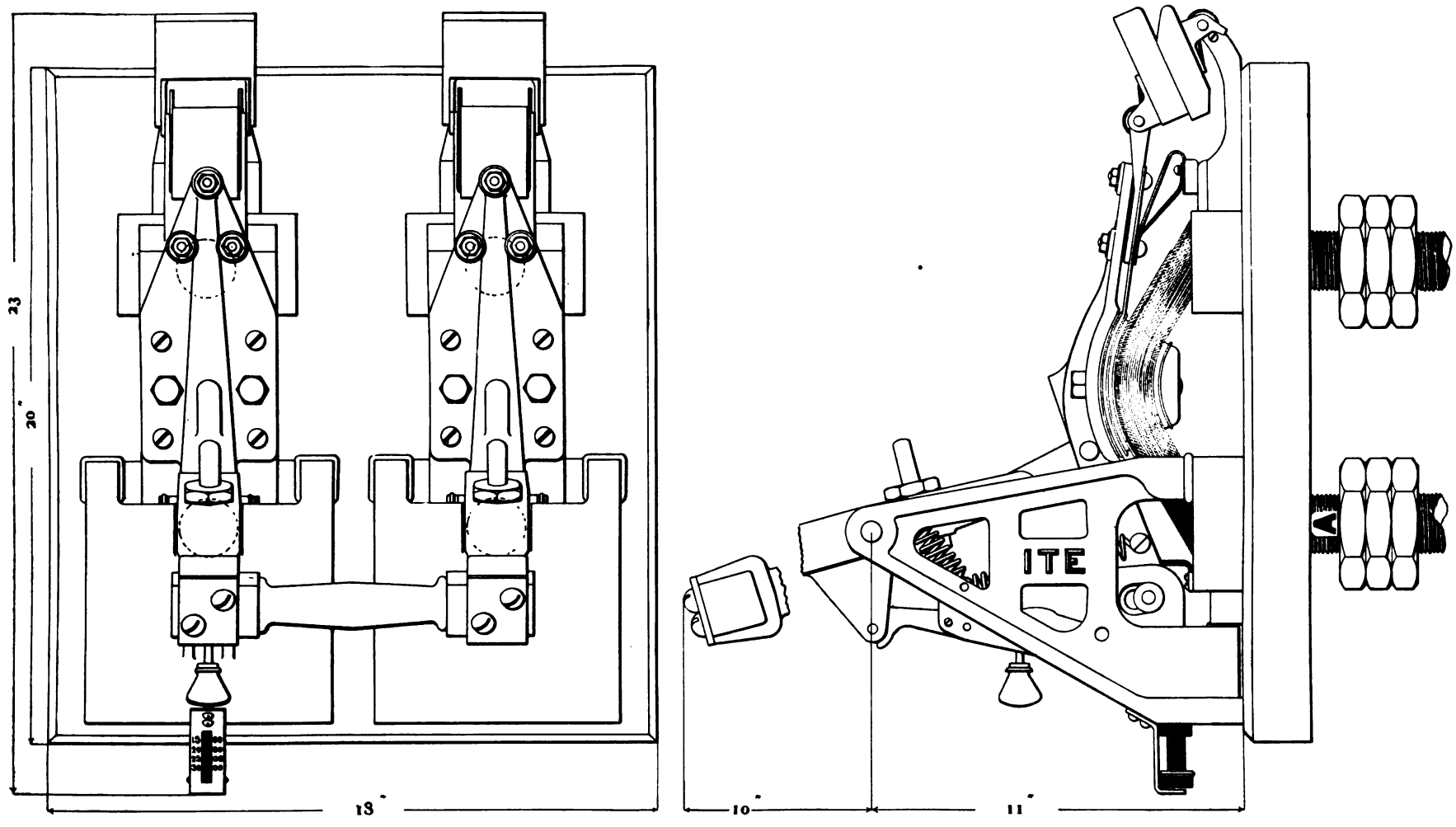
Amps.	No. of Nuts per Lead	Amps.	No. of Nuts per Lead
2000 . . . . . **1 3/4″**	**3**	**3000** . . . . . **2 1/8″**	**4**
2500 . . . . . **1 7/8″**	**4**		



I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—SINGLE POLE
"LAM" TYPE
4000 and 5000 Amperes
See Page 143, Catalogue, July 1, 1901
DIAMETER OF STUDS "A"

Amps.		No. of Nuts per Lead	Amps.		No. of Nuts per Lead
4000	**2 3/8″**	**4**	**5000**	**2 5/8″**	**4**



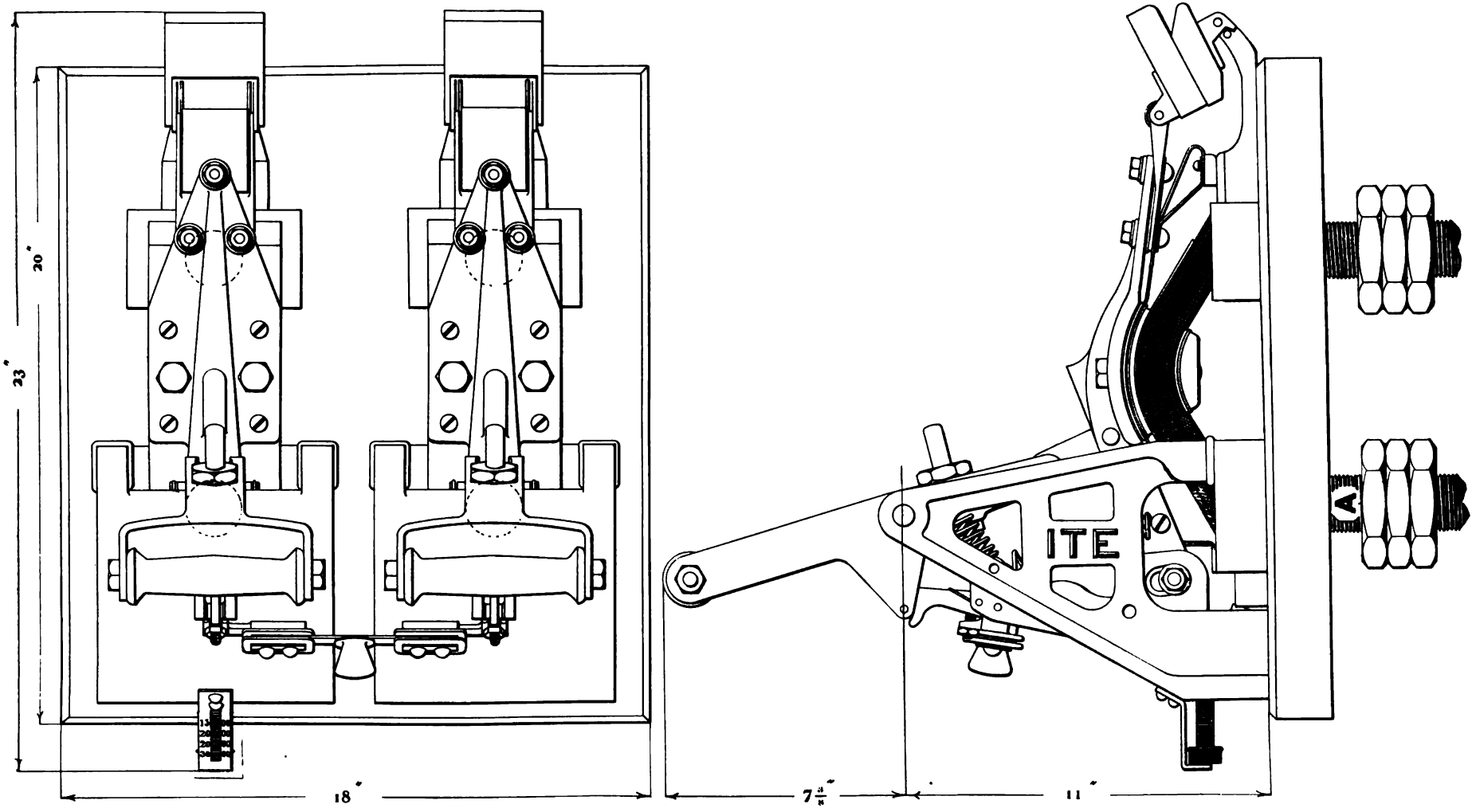
I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—DOUBLE POLE
"O-L" TYPE
2000, 2500 and 3000 Amperes

See Pages 130 and 131, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		No. of Nuts per Lead	Amps.		No. of Nuts per Lead
2000	**1 3/4″**	**3**	**3000**	**2 1/8″**	**4**
2500	**1 7/8″**	**4**			



I-T-E LAMINATED CIRCUIT BREAKER

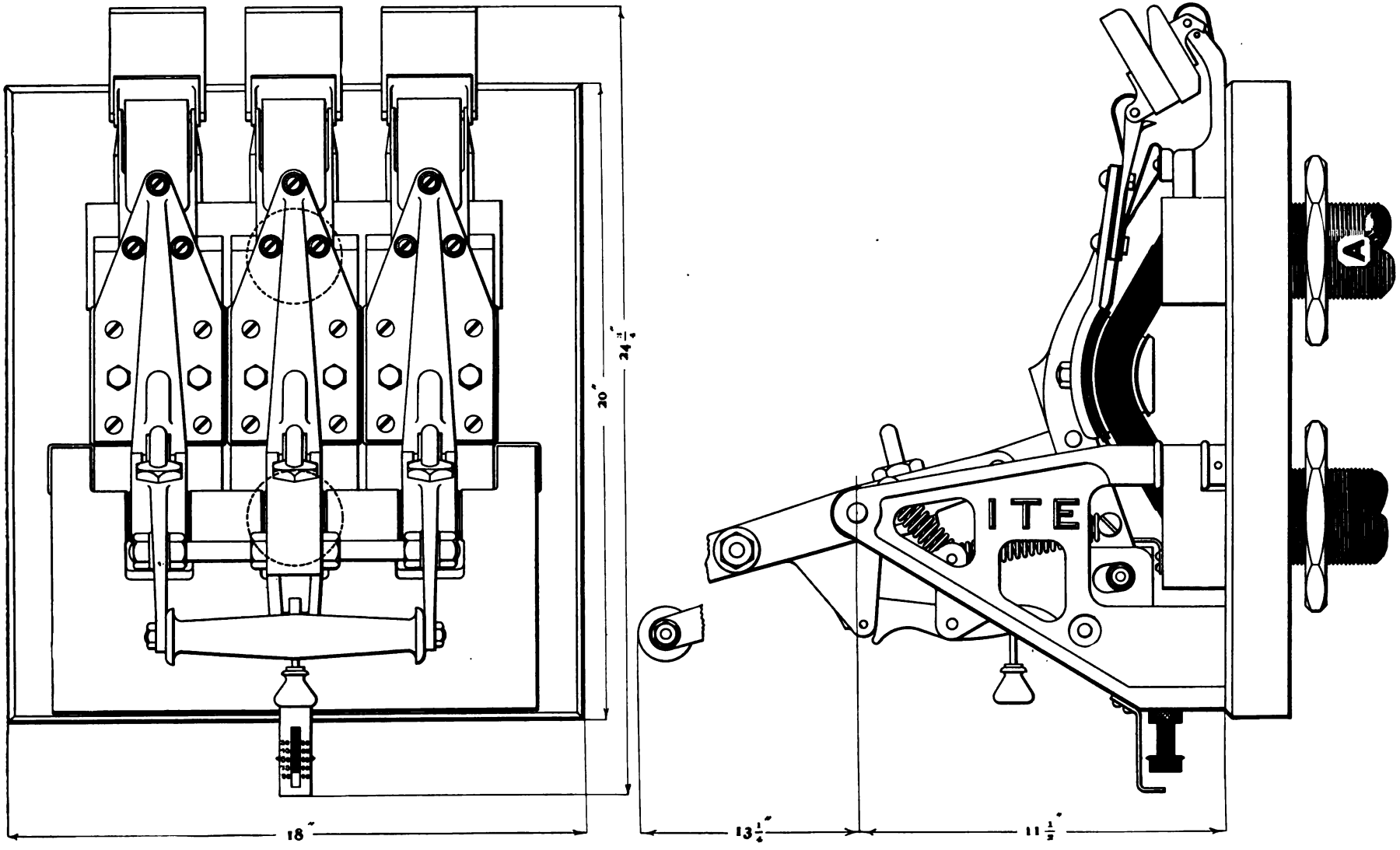
OVERLOAD—DOUBLE POLE

"P-L" TYPE

See Pages 134 and 135, Catalogue, July 1, 1901

DIAMETER OF STUDS "A"

Amps.		No. of Nuts per Lead	Amps.		No. of Nuts per Lead
2000	**1 3/4″**	**3**	**3000**	**2 1/8″**	**4**
2500	**1 7/8″**	**4**			



I-T-E LAMINATED CIRCUIT BREAKER

OVERLOAD—SINGLE POLE
"LAM" TYPE
6000 and 7500 Amperes
See Page 143, Catalogue, July 1, 1901
DIAMETER OF STUDS "A"

Amps.		No. of Nuts per Lead	Amps.		No. of Nuts per Lead
6000	2 7/8"	7	7000	3 1/8"	8

ANNOUNCEMENT

On January first we assumed the entire sales management of the line of Electrical Measuring Instruments made by the Keystone Electric Company of Philadelphia, of which Company Mr. J. Franklin Stevens, M.E., is President. We take pleasure in calling the attention of engineers to the following treatise, which has been prepared by Mr. Stevens at our request, and which we believe is worthy of your careful consideration.

On the subject of Measuring Instruments what we need is Light. We believe that the time for mystery as to Measuring Instruments is past. One does not have to be inspired to produce such a line. Brains, Capital, Care and Skill, together with the very best obtainable materials, are all that is required. All of these have gone to the making of the Keystone Instruments. The line is complete—Switchboard and Portable Ammeters and Voltmeters, Round Pattern and Illuminated Dial. The latest catalogue lists practically every type of Measuring Instrument you are likely to require, and we will take pleasure in sending you a copy. The instruments are simple and strong in construction, absolutely "dead beat," and having used them in testing I-T-E CIRCUIT BREAKERS for some time past, we feel justified, from our own experience, in fully guaranteeing them.

Since we assumed the sales management of the Keystone Instruments we have convinced a number of the most conservative engineers in the country that Keystone Instruments are not in the SECOND class, but are absolutely FIRST-CLASS in every particular. We have closed contracts for Keystone Instruments for some of the largest and most important installations undertaken during the present season.

THE CUTTER COMPANY

PHILADELPHIA AND NEW YORK

May 1, 1902.

KEYSTONE ELECTRICAL MEASURING INSTRUMENTS.

About six years ago, a prominent engineer and central station superintendent, when discussing switchboard instruments, remarked

that the strangest thing about them was that the last word still remained to be said concerning them. The same condition seems still to maintain, and we are possessed of a literature on measuring instruments which consists chiefly in didactic statements of facts, some true, some otherwise. With some few notable exceptions, both cuts and descriptive matter have tended to mystify rather than explain, and prospective purchasers have had but little information available to assist them in selecting types or systems suited to the class of measurements which they desired to make.

We believe the time for mysticism and concealment is past; for, while there may have been legitimate reasons in past years for such a policy on the part of instrument makers, there is to-day no reason why full and complete data as to principle and construction should not be made public. We do not mean to reflect on the pioneers of the art, for some of them achieved notable results when the past state of allied arts is taken into consideration, and it has only been within very recent years that the instrument-maker has

had available the materials essential to the proper construction of a scientifically designed instrument.

Copper, iron, steel, resistance metals, springs, jewels and many other constituent parts of a properly constructed instrument were known and in use, but the quality and composition left much to be desired; the demand was small and the practical application of physics and chemistry to the mechanical arts was still in its infancy. Manufacturers of raw materials could not, or would not, attempt to fill the specifications submitted to them. All this is changed to-day, and the instrument-maker can obtain every material requisite to his art, made to his specifications. This has placed the responsibility of designing and making instruments on the maker, where it properly belongs; no excuses are open to him, and we, on our part, cheerfully accept the responsibility.

We are firm believers in publicity. Our salesmen are shown just how we make an instrument; they are told why we do certain things, and why we avoid doing other things. They are shown this so they can explain it to the customer, and are supplied with sample instruments to take apart in his presence, so that he may understand just what we make and how we make it. We want our customers to know just what is inside of an instrument case, then they can decide for themselves whether or not we have done our work well.

Realizing that it is not possible to show a working model to every possible user (we wish it were so), we propose to try to dissect and to briefly describe the two principal types of instruments made by the Keystone Electrical Instrument Co., the entire sales management of which is under the control of The Cutter Company, Philadelphia and New York.

DIRECT CURRENT INSTRUMENTS.

All of our direct current instruments, whether switchboard or portable, are constructed on the principle of the Deprez-d'Arsonval Galvanometer. The Deprez-d'Arsonval Galvanometer is a modification of and a direct outgrowth from the primitive form of tangent galvanometer, the fixed and moving elements having been reversed by Dr. d'Arsonval. In place of a moving magnet under the directive force of a solenoid, we have a small moving or oscillating solenoid, under the directive force of a permanent magnet. In order that the instruments may be adapted to portable or switchboard use, springs are used as a controlling or restraining force, in place of the earth's field employed in the tangent galvanometer, and steel pivots carried in jeweled bearings are substituted for a filar suspension.

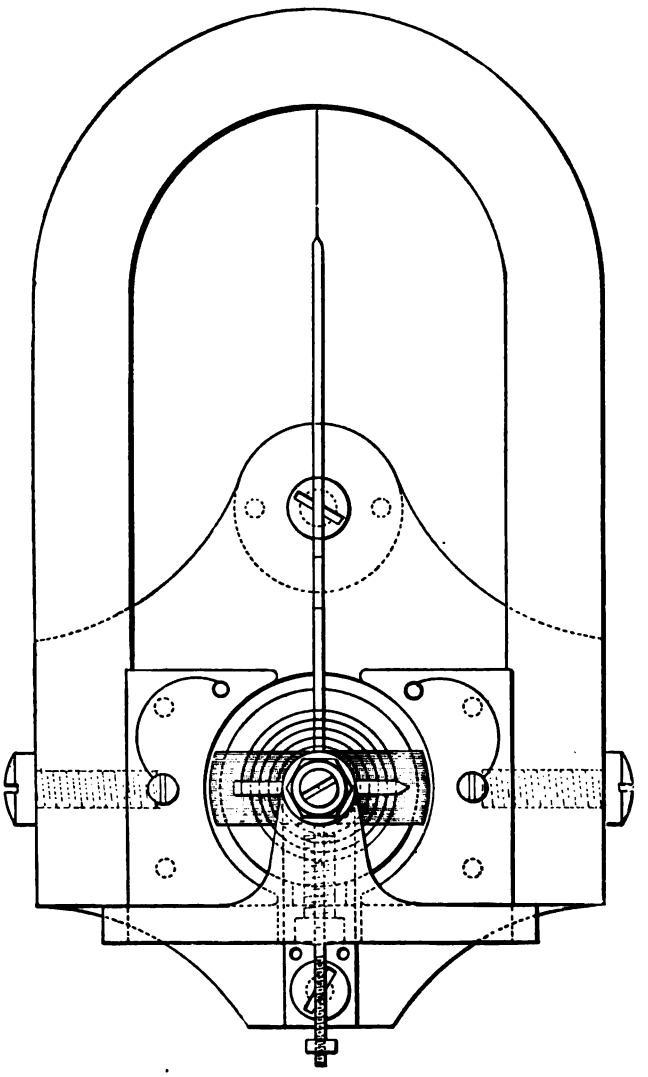


Fig. 1

The engravings shown herewith (Figures 1 to 6) illustrate the construction employed by us in all Deprez-d'Arsonval instruments, from which it will be noted

that while the original principle has been retained throughout, many structural details have been greatly improved upon, as compared with earlier types. Figures 1, 2 and 3 show very completely the construction employed; Fig. 1 being a plan view, Fig. 2 an end elevation, and Fig. 3 a section through the centre line of Fig. 1. As will be noted, the entire system is mounted upon a solid base-plate, rendering it self-contained, and independent of any deformation which might take place in the containing case. This point is of particular importance in portable types, as the wood containing case is liable to warp slightly, and such warping, even though not apparent to the eye, would change the relative positions of the different parts, causing them to bind or stick if they were separately mounted. The permanent magnet field is made of a single piece of selected magnet steel, supplied by a maker famous for his excellent work in this line. This steel is forged, machined, hardened, magnetized and aged in our own establishment, under expert supervision. We employ a very generous area and keep the magnetization below 25% of the total capacity of the steel. This enables us to produce a magnet, the permanency of which can be absolutely guaranteed. Our own experiments, and the experience of our customers, have demonstrated that there is no measurable decrease in magnetism, even after three or four years' continuous use. The pole pieces are made of soft

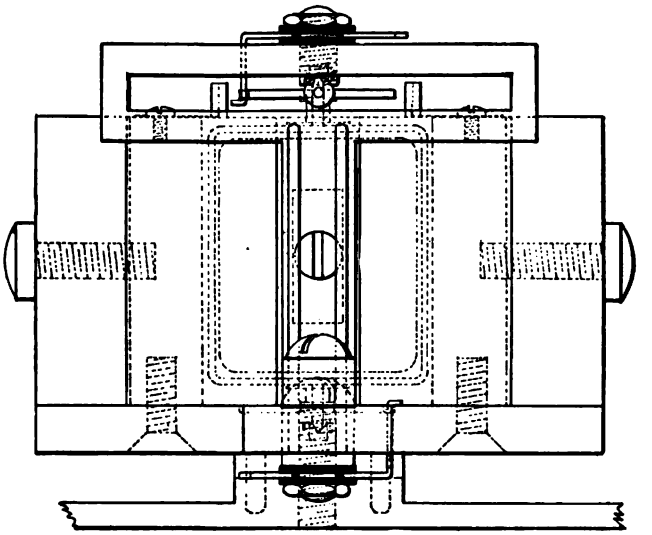


Fig. 2

steel, and are permanently secured to the magnet. The joint between the pole pieces and the permanent magnet is ground, and once made is never disturbed. This is an important feature, for a magnetic joint once broken will never possess the same resistance as when first made. On account of the large section of the permanent magnet, we are enabled to employ a generous air gap between the pole pieces and the soft iron core. This generous air gap renders it practically impossible for the moving coil to stick or bind. The entire moving mechanism is mounted separate from the field, as shown in Figures 4, 5 and 6, of which Fig. 4 is a plan view, Fig. 5 an end elevation, and Fig. 6 a side elevation. The core, it will be noted, is mounted on a cast brass bracket, which bracket also carries the moving coil, pivots, springs and jewels, so that the entire moving system can be readily lifted from the field, without danger of injury, and without the necessity of removing the pole pieces. The function of the core, as is probably well understood, is to make the field, within which the coil oscillates, absolutely uniform. The fact that the coil is completely covered by the pole pieces throughout its

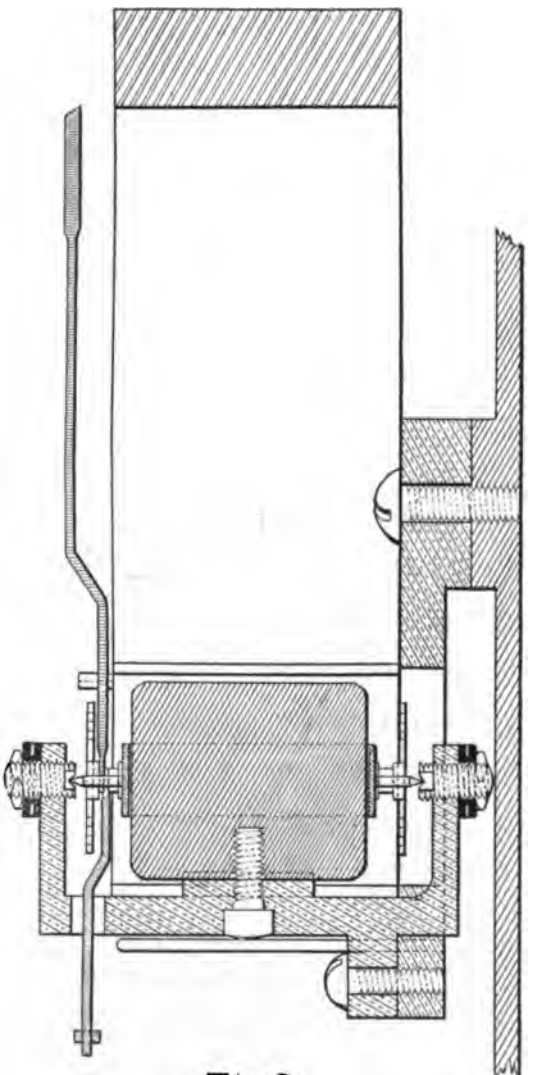


Fig. 3

entire movement, coupled with the fact that the field is uniform, makes it possible for us to obtain an equally divided scale from zero to maximum reading. The moving coil consists of a layer of copper wire short-circuited on itself, for the purpose of damping the movement of the coil by the generation of eddy currents within it, thus rendering the instrument aperiodic, or dead-beat, in its indications. The active winding of the coil, which is superposed on the short-circuited layer, consists of a number of turns of fine copper wire, to which current is conveyed by means of the controlling springs, and which, in the case of a voltmeter, is connected in series with the resistance, and in the case of an ammeter, is connected across the terminals of a shunt block. The motion of the pointer is limited by two small insulated buffer-springs, which makes it impossible for the pointer to touch the containing case and cause a bending of the pointer, or a short-circuit if the case is grounded. The jewels employed are made from the best obtainable sapphire, specially shaped and ground for our use. The pointer consists of a rod of hardened aluminum wire formed up with an eye for attachment to the axis. This construction we consider far superior to the employment of aluminum tubing, which must, necessarily, be secured by shellac or cement to a separate eye, and which possesses no elastic properties. The process of making aluminum tubing renders it necessary to anneal the aluminum, so that it is too soft to stand even a very slight shock. It will be noted that all the fixed parts of the instruments are made strong and substantial, so that there is absolutely no danger of their being injured.

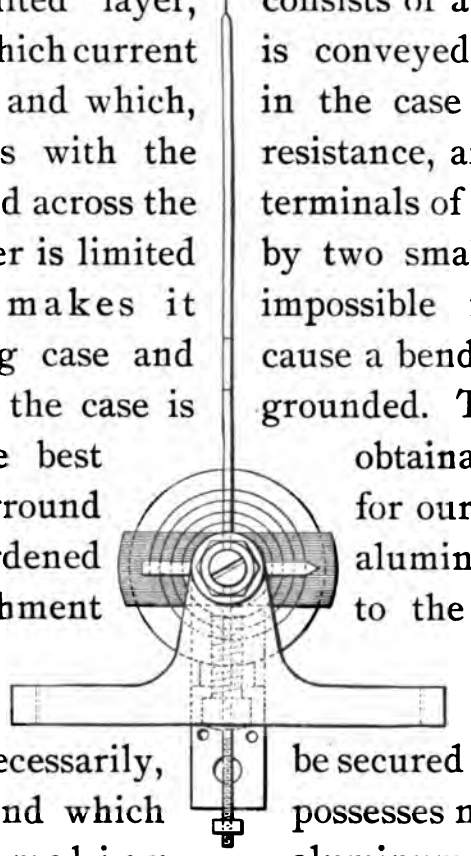


Fig. 4

The moving parts, which consist of nothing but the coil,

counterpoise and pointer, are light but strong. All parts are made to templet and all mechanical connections are made by means of screws and steady-pins.

The resistance wire employed in voltmeters and the resistance metal employed in ammeter shunts, consists of an alloy, which possesses a negligible temperature co-efficient, the actual temperature co-efficient being 1-10 of one per cent. for 100° C.

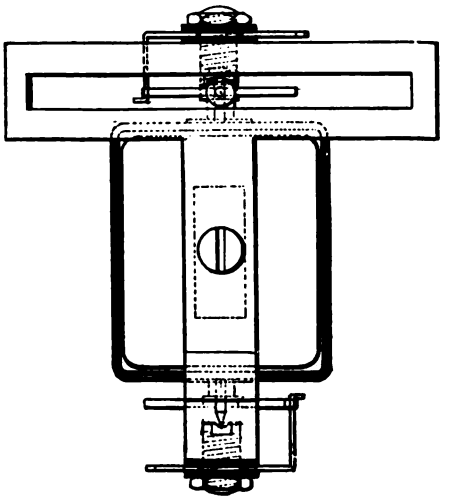


Fig. 5

ALTERNATING CURRENT INSTRUMENTS.

All of our alternating current instruments, except ammeters, are constructed on the principle of the electro-dynamometer, which principle is based on the mutual attraction between two coils through which the current passes, one of which is fixed, the other movable.

We have modified the original construction of the electro-dynamometer in several respects in order to make portable, direct-reading instruments which will be aperiodic, but have in no way sacrificed the inherent good qualities of the dynamometer system.

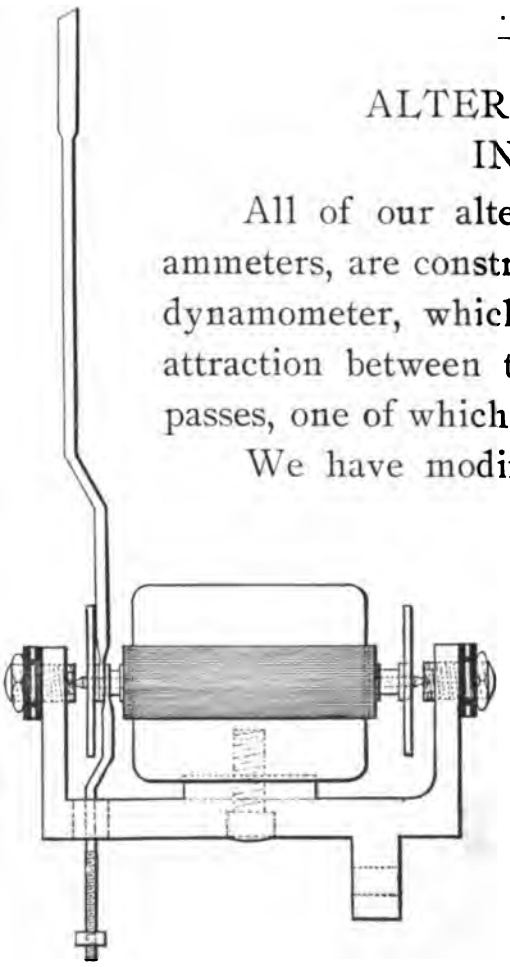


Fig. 6

As the governing law of this type of instrument is the law of current squares, it follows that in the case of voltmeters equally divided

scales cannot be obtained. In the case of wattmeters the scale is approximately equally divided, due to the fact that the movement of

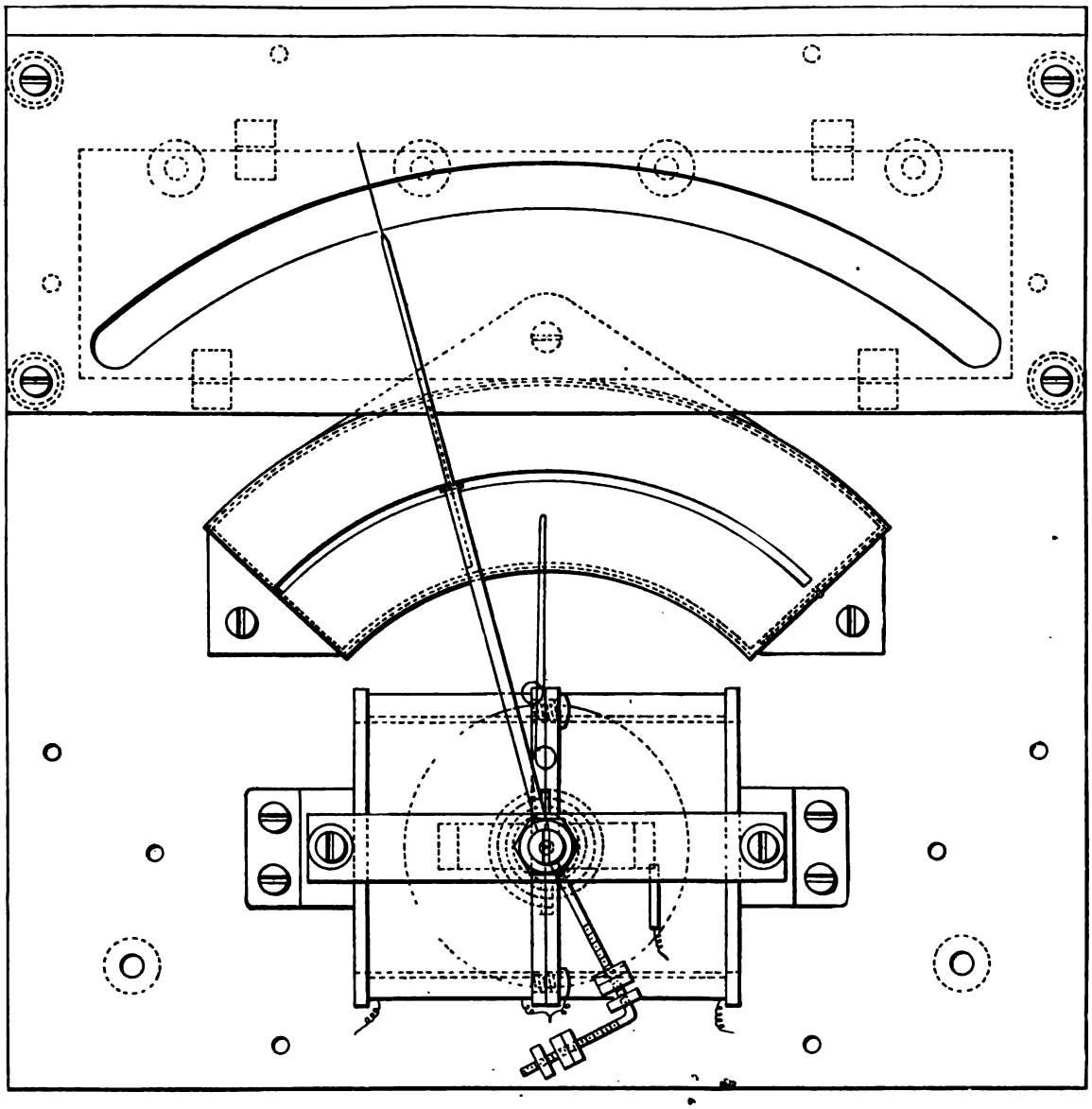


Fig. 7

the moving coil is proportional to the product of the current in the fixed and moving coils.

We have, however, succeeded in obtaining more nearly equally

divided scales than has heretofore been considered possible, due to the employment of our patent combined system of springs. This spring system consists of one spiral spring and a spring which we term a pendulum spring. These two springs are so related to one another that the pointer when at zero is held in what may be termed a dynamic state of rest rather than in a static state of rest. The spiral spring uniformly opposes the movement of the moving coil, while the pendulum spring assists the movement of the moving coil through the first half of the scale, then acts with the spiral spring and helps oppose its movement through the second half of the scale. From this it follows that the control is weak when the deflecting forces are weak, and automatically increases in strength as the deflecting forces increase in strength.

The moving parts have been made as light in weight as is consistent with mechanical strength, and the entire moving system is supported in jeweled bearings. The motion of the pointer is rendered aperiodic by the use of an aluminum air vane moving in

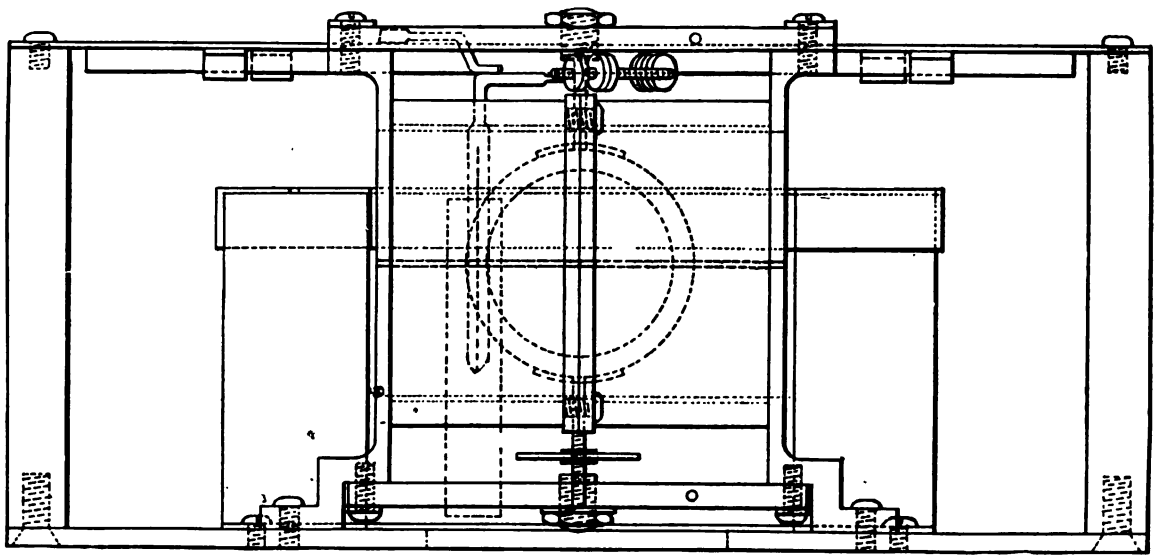


Fig. 8

a partially enclosed air chamber. This method of damping the oscillations of the moving parts renders unnecessary the use of mechanical brakes or other frictional devices, which tend to impair the accuracy of the instrument.

It is essential that instruments of this type should be carefully designed in order to obtain the proper proportions between fixed

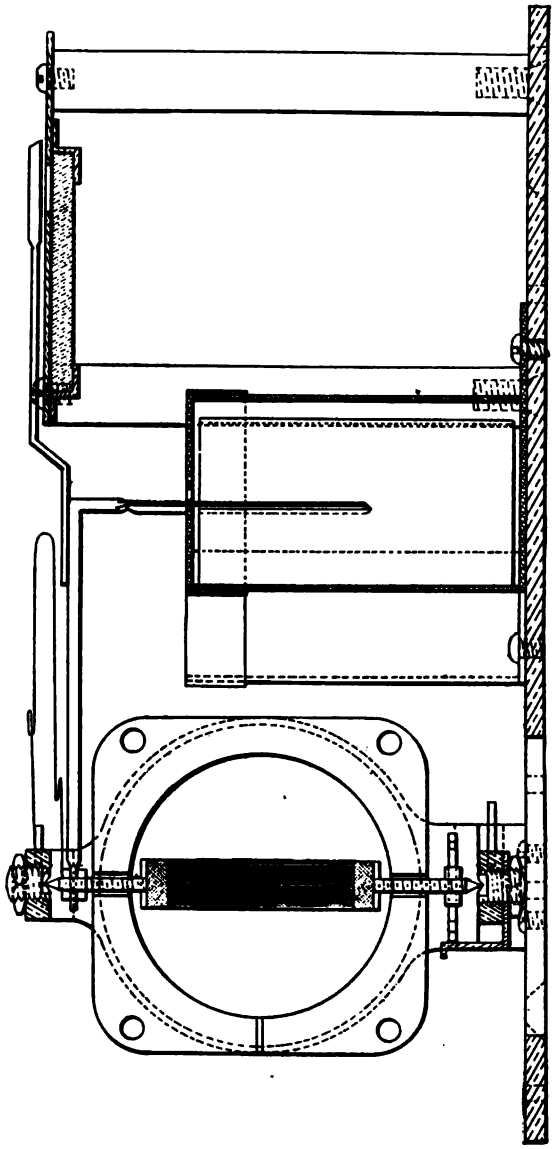


Fig. 9

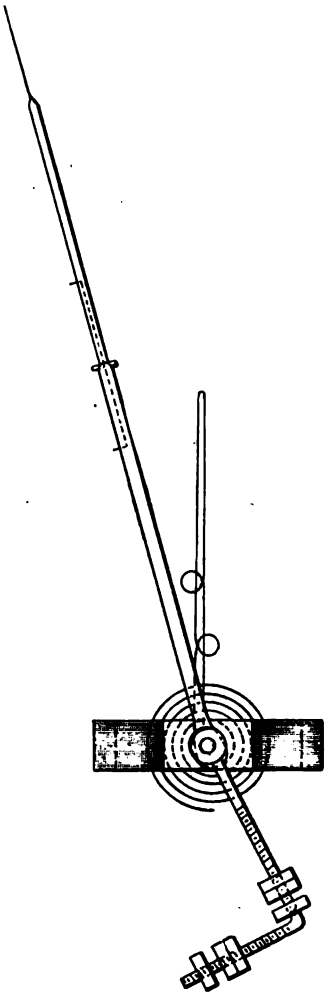


Fig. 10

and moving coils, and the proper proportions between inductive and non-inductive resistance. We have succeeded in producing a line of instruments in which we believe these proportions are as nearly perfect as it is possible to obtain, with the result that we are able to offer an instrument high in resistance, accurate and efficient, yet so proportioned that the inductive resistance is so small compared with the non-inductive, that errors due to self-induction and phase displacement are not introduced.

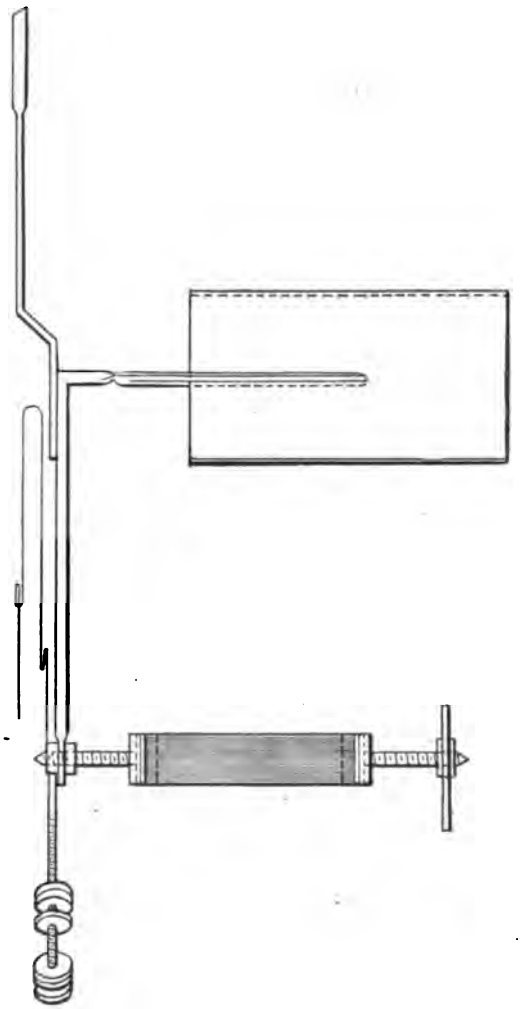


Fig. 11

The construction of this type of instrument is illustrated in Figures 7 to 12. Fig. 7 shows a plan view of a portable voltmeter, Fig. 8 an end elevation and Fig. 9 a section through the centre line of Fig. 1. The moving elements are shown in Figures 10, 11 and 12, which show the coil, pointer, damper, springs, etc., in plan, side elevation and end elevation respectively. The engravings show a voltmeter, which, however, differs but little from a wattmeter. In the case of a wattmeter, the fixed coils are connected in series with the line, either directly or through a series transformer, while the moving coil is connected in shunt to the line.

While it is true that the reading of the wattmeter represents the product of the readings of the voltmeter into the ammeter in the case of direct current measurements, it is not true in the case of alternating current measurements, save in the very exceptional case of a circuit possessing neither capacity nor inductance, or a balance of the two. When either inductance or capacity exist, there is a consequent lag or lead of the current wave relative to the pressure wave; and since the instantaneous readings of the volts and amperes represent the mean effective or virtual values—that is, the square root of the mean square, their product differs from the reading of the wattmeter, which indicates the integrated values of the two curves, the maximum and minimum values of which occur at different times. To obtain an agreement between the values obtained by volt-ampere readings and watt readings, it is necessary to multiply the volt-ampere readings into the cosine of the angle of lag or lead, so that the ratio of the watt readings, as given by a properly constructed wattmeter, to the volt-ampere readings gives us the power factor of the circuit, and from the two sets of readings we can readily determine the angle of the lag or lead and the so-called wattless current.

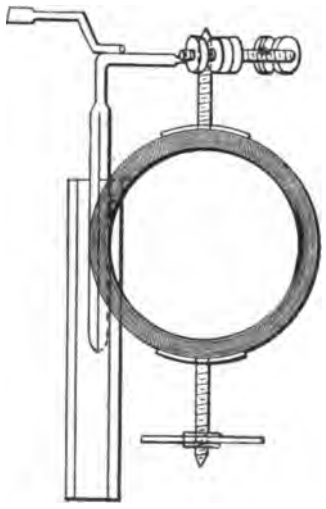


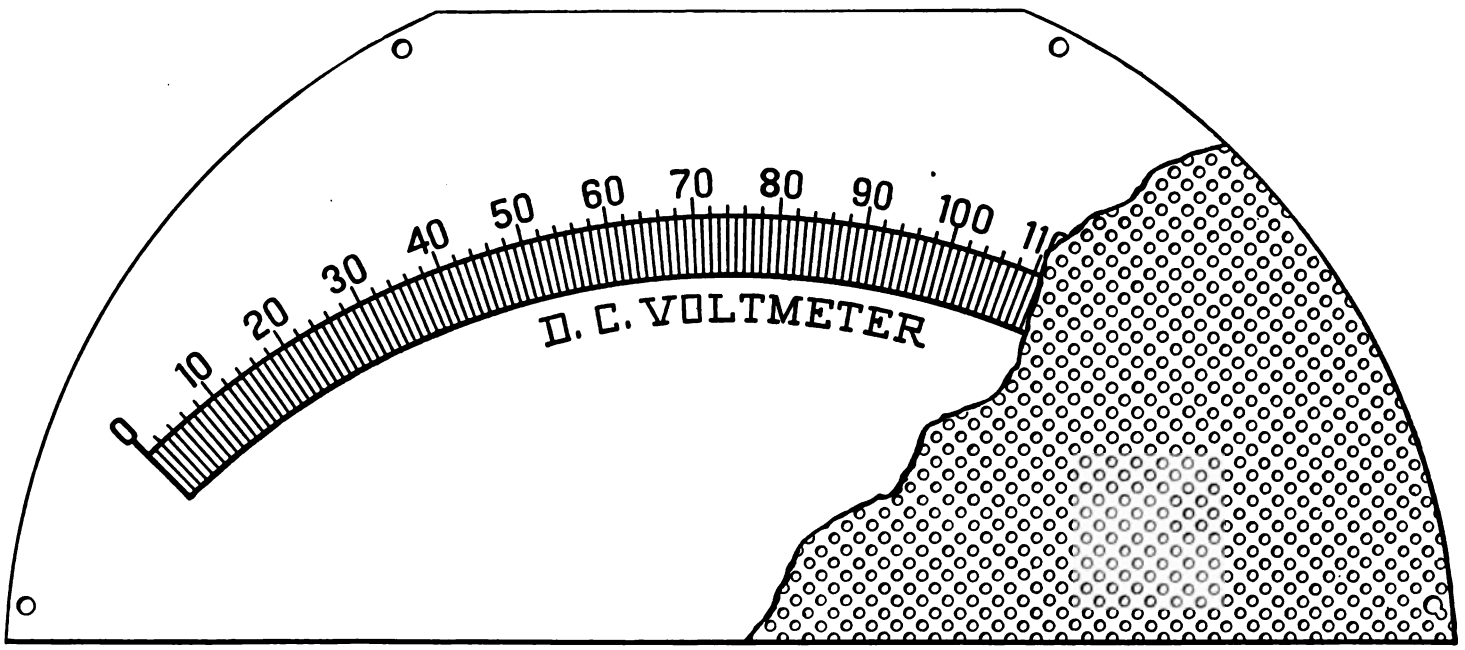
Fig. 12

In addition to voltmeters and wattmeters, we have adapted the dynamometer type of instrument, by means of suitable connections and by the use of inductances and condensers, to the measurement of frequency and power factors and to indicate synchronism between alternators operated in parallel. Any of the above instruments are adapted for use on single phase, two phase, three phase or polyphase circuits, as may be specified.

SCALES AND CALIBRATION.

Two forms of scales are commonly employed in indicating instruments, one drawn on opal glass, for use in instruments in which the scale or dial is illuminated by means of an incandescent lamp placed behind it, and the other drawn on bristol board, for use in instruments in which the illuminated feature is undesirable or unnecessary.

In illuminated dial instruments, the opal glass scale is self-supporting; but where bristol board is employed, it is necessary to secure it to a metal backing or scale plate in order to obtain the requisite rigidity. Heretofore, it has been customary to secure the bristol board to a plain plate of brass or zinc by means of shellac or some similar cement, but it has never been possible to find a cement which would perfectly and permanently secure a semi-impervious substance like bristol board to an impervious metal. The bristol



PATENT APPLIED FOR

Fig. 13

board would raise or blister, particularly when subjected to moisture or dampness, and, as the clearance between pointer and scale is necessarily small, this raising of the bristol board would cause the pointer to stick or bind on the scale, thus introducing errors in the indications of the instrument or rendering it entirely inoperative.

In order to obviate this defect we have designed and have patent applications pending upon a new and novel method of securing the bristol board to the scale plate. The construction is shown in Fig. 13, from which it will be noted that the scale plate consists of perforated metal, to which the bristol board scale is secured by shellac or similar cement. The perforations in the metal permit the cement to come through and form, as it were, almost innumerable flexible rivets which secure the bristol board rigidly and permanently on the same general principle employed in keying plaster to a wall by the use of wooden or metal lathing.

Repeated experiments have shown that a scale so secured will never warp or blister, nor can it be pulled away from its metal backing, so that all the errors and annoyances due to loose scales are entirely obviated.

In the use of measuring instruments in damp places, in storage battery rooms, in fortifications and in marine work, particularly, this important detail of construction makes Keystone Instruments especially desirable. It is, however, only one evidence of the care which is everywhere apparent in their construction.

All instruments are enclosed in dust-proof and relatively moisture-proof cases, and for marine use cases are rubber-gasketed to make them absolutely water-proof. As an additional precaution, we float all scales for marine instruments with a colorless varnish, so that even submersion in water cannot affect their surfaces or cause stretching and shrinking of the bristol board.

All instruments are calibrated by direct comparison with standard instruments which are kept in constant check with fundamental standards of current and voltage. Our laboratory is very perfectly equipped in this respect, and every facility is at hand for making direct tests and comparison of voltage, current or resistance.

All scales are drawn in by hand, and every numbered point on each scale is determined by comparison with a standard instrument of suitable range. Intermediate points are put in by means of the curve of calibration, which is checked before an instrument is sealed, and each instrument is accompanied by a certificate of accuracy. In the case of voltmeters, the resistance is stated so that they are made available for testing or comparing resistances and for the many other purposes outside of mere voltage determinations.

The above illustration shows a back view of our Type "K," illuminated dial, voltmeter and ammeter, the front view being the same as that shown on page 1. The scale is drawn on opal glass, and is illuminated by means of a standard 16 c.p. incandescent lamp. The lamp is so located that the scale is uniformly illuminated without shadows.

SELECTION, USE AND CARE OF ELECTRICAL MEASURING INSTRUMENTS.

The proper use and care of electrical measuring instruments involves, in the first place, the selection of the particular type, style and range of instrument best suited for the measurements to be made, with due consideration to the conditions under which the instrument must operate.

The selection of the proper style of switchboard instrument depends, primarily, upon the taste of the purchaser, with due consideration to the installation in which the instrument is to be used. Size, shape, finish and character of scale are questions which can only be decided when considered in connection with the entire installation. We believe we make a sufficient variety to enable a selection which will harmonize with the switchboard fittings, and which will be in consonance with the general scope and plan of any lighting or power plant. At times, of course, the question of price becomes an important factor, and in this respect we have endeavored to give as large a range of selection as we have in the appearance and size of the instruments themselves.

We are quite well aware of the fact that individual instruments may be purchased at lower prices than we are able to name. Our plan, however, has been to first design the instrument and ascertain for just how little that instrument can be produced, and then, based on that, we have fixed our selling price. We have consistently avoided fixing a selling price first, and endeavoring to construct an instrument which would fall within the price so set. We firmly believe that in the selection of so important an adjunct to an electrical installation, it pays to make and buy only the best; and with that end in view we have established one standard for all of

our instruments, irrespective of the selling price. Features present in one type may be absent in another, but the base construction of every instrument is the same as for every other instrument in its own particular class. All material entering into the construction of any of our instruments is the best we are able to obtain, and the workmanship employed the most skilled that the labor market affords.

We realize fully that our reputation rests on the instruments we turn out from day to day, and that our only hope of future success lies in the continuance of the policy adopted at the outset; which is, to give an honest dollar's worth of finished product for every dollar paid to us, and to treat every customer who comes to us with justice and with courtesy.

We cannot hope, in the brief space at our disposal, to attempt to describe every possible condition under which an instrument can or cannot be used, and to indicate the particular type or system best suited for such conditions. Our remarks here must necessarily be limited, but we are always ready and willing to take up and discuss with our customers any of the questions which may arise in practical work, and to place at their disposal any experience we may have gathered during the years we have been in this particular line of business.

In the matter of the selection of instruments for any particular class of service, we can say that our portable instruments classify themselves. For direct current measurements there is no system so well adapted to all conditions of use as the Deprez-d'Arsonval. These instruments possess the advantage of having equally divided scales, so that for every unit increase in current there is an equal angular deflection of the moving coil and pointer. They are necessarily well shielded from the influence of external fields, due to the intense field produced by the permanent magnet in the instrument.

In this particular type of instrument we have reverted to a construction which was formerly found to be satisfactory, but which later was abandoned by some manufacturers on account of its cost; that is, the employment of a heavy magnet of generous area, high permeability and high retentivity. The employment of such an intense field enables us to employ a solid and strong moving system, and, further, enables the use of an air gap sufficiently wide to obviate the danger of the moving coil binding, due either to any slight deformation of the coil or to the presence of any small particles which may find their way in between the pole pieces and core.

This type of instrument is readily made aperiodic in its indications, and, when properly designed, possesses a very high resistance, in consequence of which the power consumption necessary to operate the instrument is almost infinitesimal. With the Deprez-d'Arsonval type of instrument it is possible to make a large variety of measurements; for instance, with a voltmeter and ammeter, not only voltage, current and power may be measured, but likewise resistances, leaks and many other properties of the apparatus or circuit under test.

Another advantage possessed by this style of instrument is the fact that they may be so readily adjusted for ranges other than the calibrated range by the employment of extra shunts or resistances. For temporary use, these extra shunts or resistances can be readily constructed by any skilled mechanic; but for continued use, or where accuracy is an important feature, they should be constructed and tested by the manufacturer of the instrument, who possesses the requisite laboratory facilities. These extra attachments, which so greatly increase the value of the instrument, cost but little, and can be readily furnished for use with any instrument. When such extra appliances are desired, the serial number and range of the

instrument should always be specified, in order that we may be able to make proper adjustment from the record which we keep of every instrument shipped.

All of the above applies to Deprez-d'Arsonval switchboard instruments, quite as well as to portable instruments.

Alternating current portable instruments cannot be made with equally divided scales, but outside of this possess many of the advantages of the Deprez-d'Arsonval system, with the additional advantage that they may be used on either direct or alternating current circuits with equal accuracy.

By the use of a combination portable voltmeter, ammeter and wattmeter it is possible to study all of the important features of an alternating current circuit. The fact that the volt-ammeter readings as determined by a voltmeter and an ammeter, when compared with the watt readings as indicated by a wattmeter, show the power factor of the circuit, and, by a simple proportion, indicate the angle of lag or lead, enables the user to study in detail every portion of the circuit under test, and to measure accurately the losses in transmission or in the translating devices employed.

The electro-dynamometer system, as used in portable instruments, is also well adapted for switchboard use on alternating current circuits.

In handling or installing electrical instruments, it should be remembered that electrical indicating instruments are necessarily delicate in their construction. This may be appreciated when it is remembered that the instrument-maker has at his disposal, as a rule, but little more than one watt in order to operate the instrument at full scale. This consumption of energy varies somewhat with the type and range of instrument, falling as low as a fractional part of one watt and never exceeding five watts. It is, of course,

important that the watt consumption within the instrument should be small, not only for the purpose of saving a constant expenditure of energy, but, likewise, for the purpose of making the instrument more accurate in its indications. The less power taken from a circuit by the device employed to measure the power within the circuit, the nearer the indications will be to absolute accuracy.

Aside from the matter of power consumption within the instrument, it is necessary that the moving parts should be light and delicate in order to obtain a satisfactory degree of "dead-beatness," and from the lightness of the moving parts follows the necessity of most carefully polished pivots carried in bearings of the best obtainable sapphires. All stationary parts of our instruments are solidly built and firmly secured to one another, so that all the delicacy is confined to the moving elements.

We think we have demonstrated the fact that we have succeeded in finding a happy medium in the matter of the moving parts, and our experience has shown that if the instruments are properly handled they will remain accurate indefinitely; but we wish to impress on all users that indicating instruments are entitled to the same care in handling that would be given a high-grade watch or chronometer. All instruments are very carefully packed by us in stout boxes, the instrument being protected on all sides by not less than two inches of fresh, clean excelsior, and, as noted on the packing advice which accompanies every instrument, they should be repacked as carefully as when received, whenever it may be necessary for the consignee to reship them to other points. Time and money will be saved by shipping instruments by express rather than by freight, due to the fact that greater care is given the instruments during transit. Instruments should never be shipped attached to the switchboard on which it is proposed to use them.

In foreign shipments, the cases containing instruments should not be opened until they reach the point of destination. This is due to the fact that for all foreign or water shipments the instrument is enclosed in a metal case, hermetically sealed and surrounded on the outside with a wooden packing case. It is almost impossible to reseal this metal case after it has once been opened, and it is essential in marine shipment that the instrument should be protected from moisture and water.

Portable instruments should never be used in the neighborhood of strong magnetic fields. The effects of a strong magnetic field on a Deprez-d'Arsonval instrument is liable to permanently change its indications. No permanent injury will be done to a dynamometer system, but the indications will not be correct while in the presence of the strong external field.

Dropping a portable instrument almost invariably results in injuries to the pivot points or jewels, which render a recalibration advisable.

It is no longer considered good practice to attempt to club an instrument into submission. Modern instruments can be depended upon to indicate correctly without the necessity of external persuasion.

In using either switchboard or portable instruments the glass which covers the scale should not be rubbed or polished before taking a reading, due to the fact that such a rubbing induces static charges in the moving parts, which static charges interfere with the accuracy of the indications until they are dissipated. Static charges accidentally induced may be removed by touching the finger lightly on the glass immediately above the pointer. The dissipation of the static charges will be shown by the pointer returning to zero.

As we have said before, all instruments shipped by us are

sealed, not only for our own protection, but, likewise, for the protection of the purchaser, in case the instrument should be used by employees or associates. There is no occasion for any user to open an instrument, and, as can be readily appreciated, we cannot assume responsibility for the performance of instruments which have been opened by customers. Our guarantee stands back of every instrument shipped by us, and we agree, for the period of one year from date of shipment, to replace, free of charge, any defective parts, or to repair any damage due to the use of defective material or defective workmanship. We would like to impress upon all customers the fact that while instruments may be returned to us for repair, under our guarantee, with seals unbroken, and presenting no external evidence of injury, yet we are able, in almost every instance, to locate the cause of trouble. An examination of any instrument by its maker enables him to tell at once why the instrument did not operate, and whether the reason for its failure to operate is due to defective workmanship or material, or is due to misuse on the part of the customer. We have many times made repairs, for which no charges have been rendered, when the fault was clearly not our own, due to the fact that the party returning the instrument refused to be honest in the matter, insisting that the instrument had not in any way been misused, notwithstanding the fact that its condition showed plainly that it had, and showed just exactly what the misuse had been. Such cases, of course, show the character and disposition of the party with whom we may happen to be dealing, and we naturally reserve to ourselves the right of forming our own opinion as to their honesty and desirability as customers.

We believe it will pay engineers and contractors to study carefully the question of the proper location of switchboards,

placing them so that they are not subject to the influences of any external magnetic fields, and mounting them on solid foundations which are not connected in any way with the dynamo foundation. This latter point is important; for, if there is any vibration transmitted to the switchboard, the instruments will receive more frictional wear in one day from a vibrating board than they will receive in a year of actual indication on a steady board.

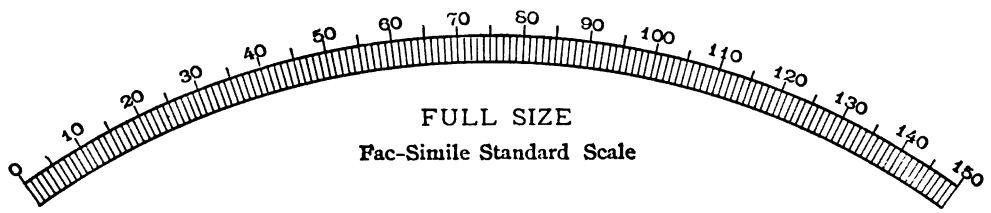
Many articles have been written which attempt to give methods for testing switchboard instruments in central stations or isolated plants, but in nearly every case the methods or apparatus described are impracticable. Circuits cannot be opened indiscriminately, and laboratory apparatus and methods cannot be successfully employed in an operating plant. The simplest and most satisfactory plan is to test by means of portable instruments of proper range in connection with suitable shunts or multipliers. The portable instruments possess the advantage of being direct reading and easily put into circuit. They should be most carefully treated, and kept as check or standard instruments. Such instrument, as a matter of precaution, should be returned to the manufacturer not less than once a year for checking. This service costs very little and constitutes an absolute guarantee against errors. By means of such portable instruments it is possible to test indicating, registering or recording instruments of any type or make for accuracy, for the influence of external fields, for temperature errors due either to internal heating from the passage of current through them, or due to external heating from changes in the ambient temperature. Electro-magnetic instruments may be tested for errors due to lag or hysteresis on direct current circuits, or for errors due to self-induction on alternating current circuits. The methods of making such tests are well understood, but care should be taken that the

portable instruments are not subjected to the same conditions of temperature or magnetic influence as the instruments which are being tested.

In order to show clearly the different laws which govern different types of instruments, we show graphically on the next page the curves of calibration of the Deprez-d'Arsonval, electro-dynamometer and electro-magnetic systems. It will be noted that each type follows a well-defined law, and that each scale should show the presence of that law in its calibration. While we never attempt to force a calibration nor employ engraved scales, we draw the curve of calibration for every instrument, as a check on the accuracy of the calibrating department and as a guard against possible error. If any instrument does not follow its law, there is something wrong in either the design or construction. This point should be noted by users; for when instruments of the same type show variations from their law, evidenced by the spacing and arrangement of the scale divisions, there is something inherently wrong.

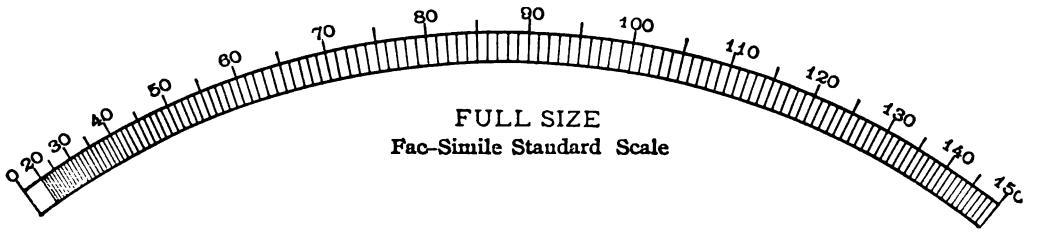
The practical application of curves A and C are well illustrated in the calibrated scales shown on this and the following page.

DIRECT CURRENT PORTABLE VOLTMETER.



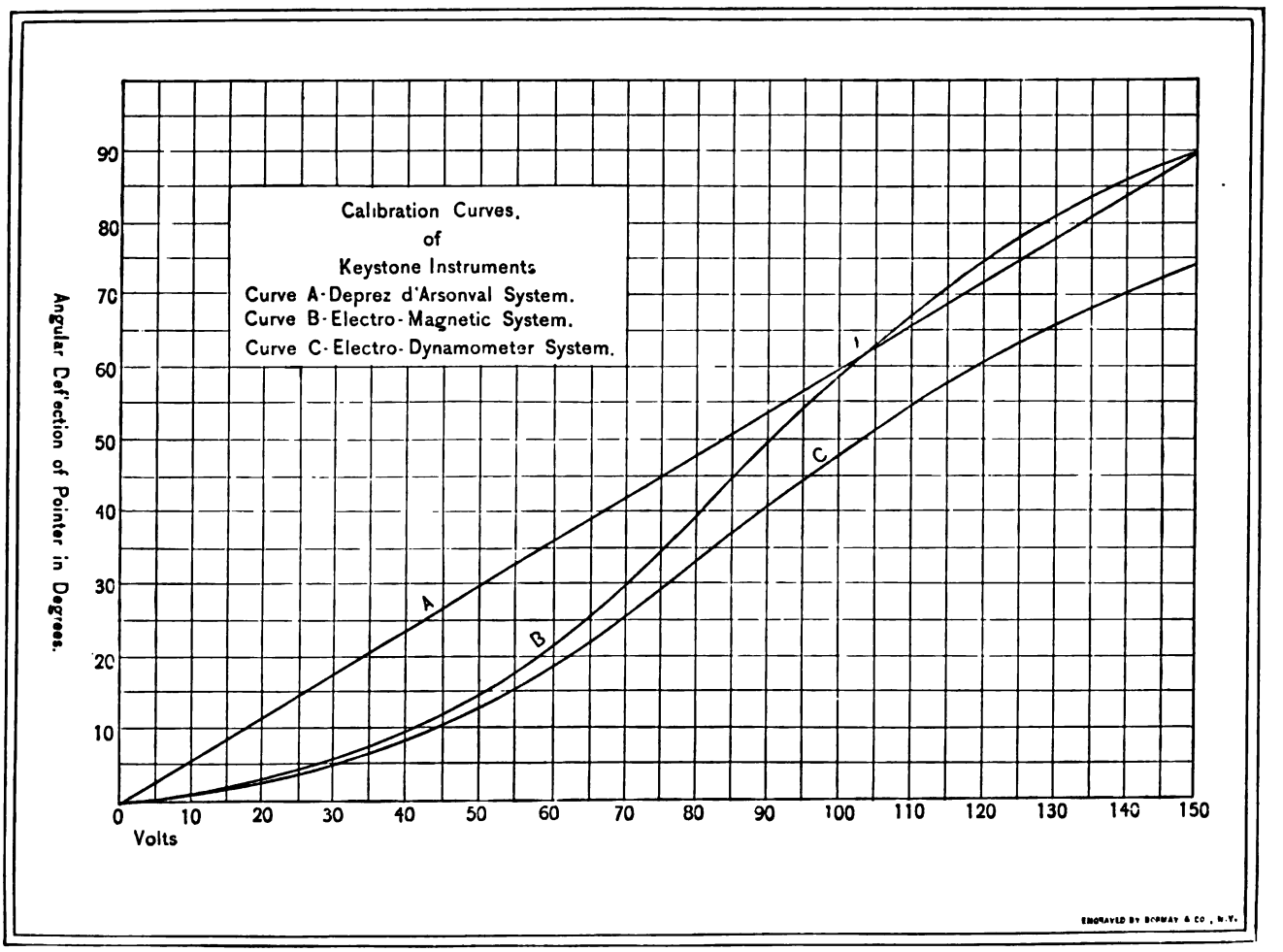
DEPREZ-d'ARSONVAL SYSTEM (CURVE A).

ALTERNATING CURRENT PORTABLE VOLTMETER.



FULL SIZE
Fac-Simile Standard Scale

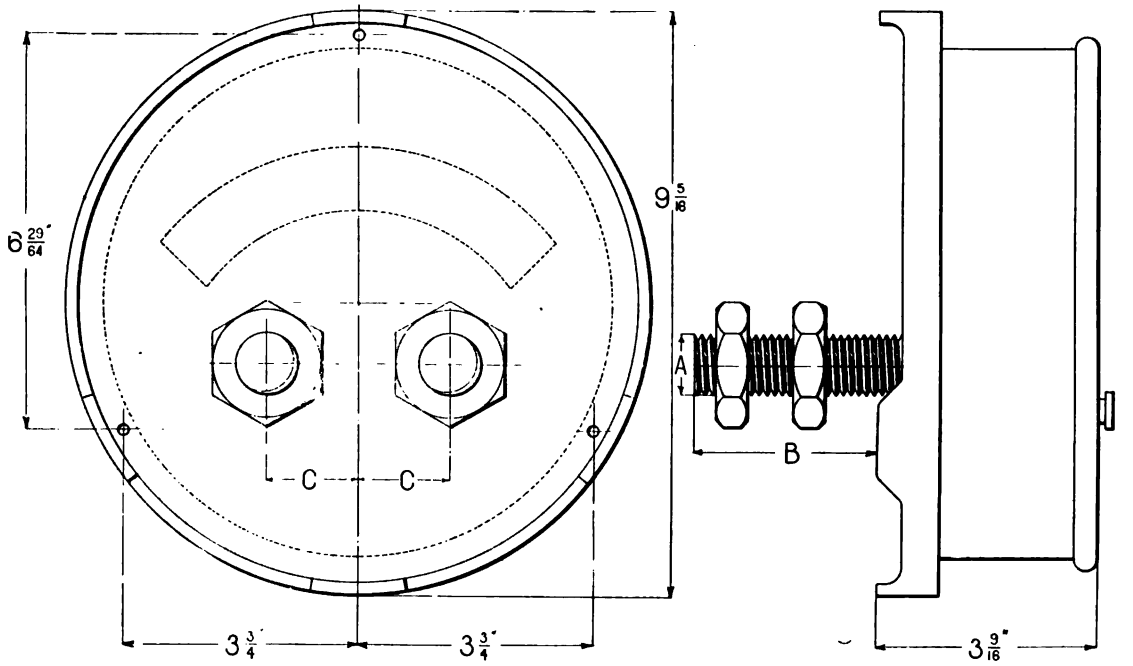
ELECTRO-DYNAMOMETER SYSTEM (CURVE C).



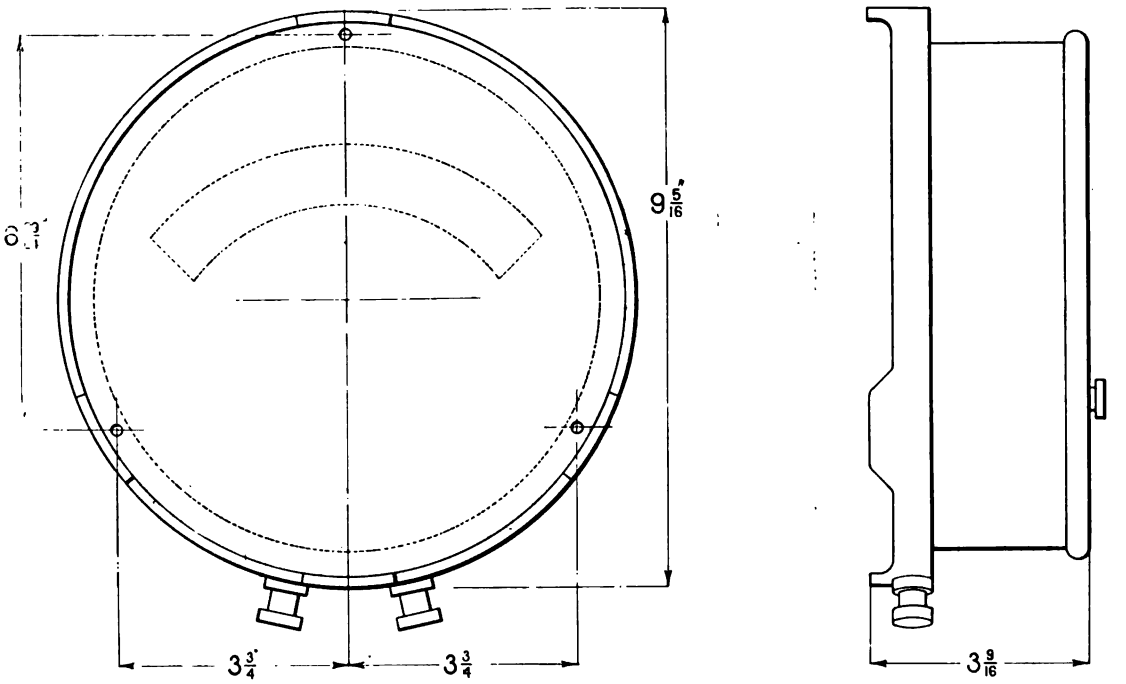
DIMENSIONAL DIAGRAMS OF

KEYSTONE MEASURING INSTRUMENTS

DIMENSIONAL DIAGRAMS
Type R Series Ammeter



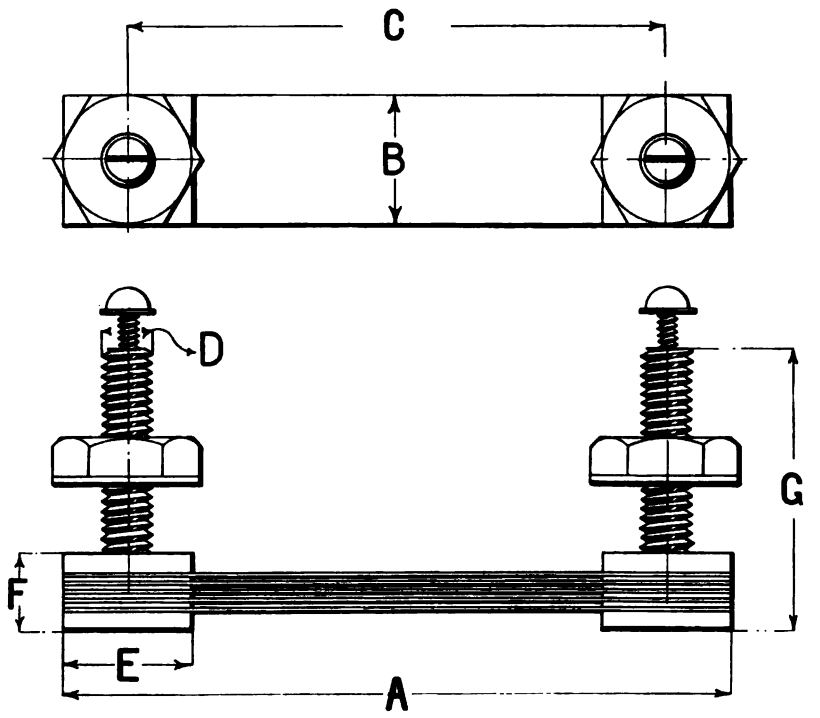
DIMENSIONAL DIAGRAMS
Type R Voltmeter and Shut Ammeter



The above instruments are also made in Flush Types

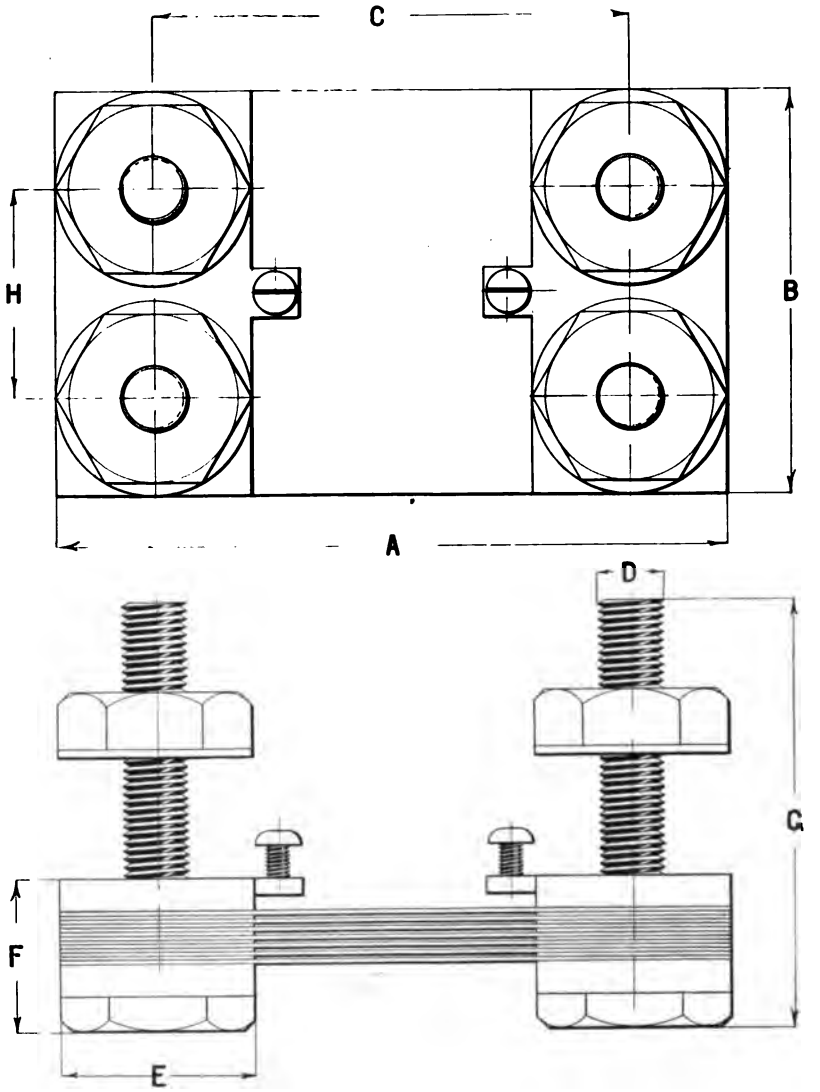
DIAGRAM OF SWITCHBOARD

Ammeter Shunt



Amperes	A	B	C	D	E	F	G
75	6 "	1 "	5 "	3/8 "	1 "	9/16"	2 1/8 "
100	6 1/2 "	1 1/4 "	5 1/4 "	1/2 "	1 1/4 "	9/16"	2 5/8 "
150	6 "	1 "	5 "	3/8 "	1 "	1 1/16"	2 1/8 "
200	6 1/2 "	1 1/4 "	5 1/4 "	1/2 "	1 1/4 "	1 1/16"	2 5/8 "
250	6 "	1 "	5 "	3/8 "	1 "	1 3/16"	2 1/8 "
300	6 1/2 "	1 1/4 "	5 1/4 "	1/2 "	1 1/4 "	1 3/16"	2 5/8 "
400	6 1/2 "	1 1/4 "	5 1/4 "	1/2 "	1 1/4 "	1 5/16"	2 5/8 "
500	6 1/2 "	1 1/4 "	5 1/4 "	1/2 "	1 1/4 "	1 1/16"	2 5/8 "
600	8 "	2 1/2 "	6 "	3/4 "	2 "	1 3/16"	3 1/8 "
800	8 "	2 1/2 "	6 "	3/4 "	2 "	1 5/16"	3 1/8 "
1000	8 "	2 1/2 "	6 "	3/4 "	2 "	1 1/16"	3 1/8 "

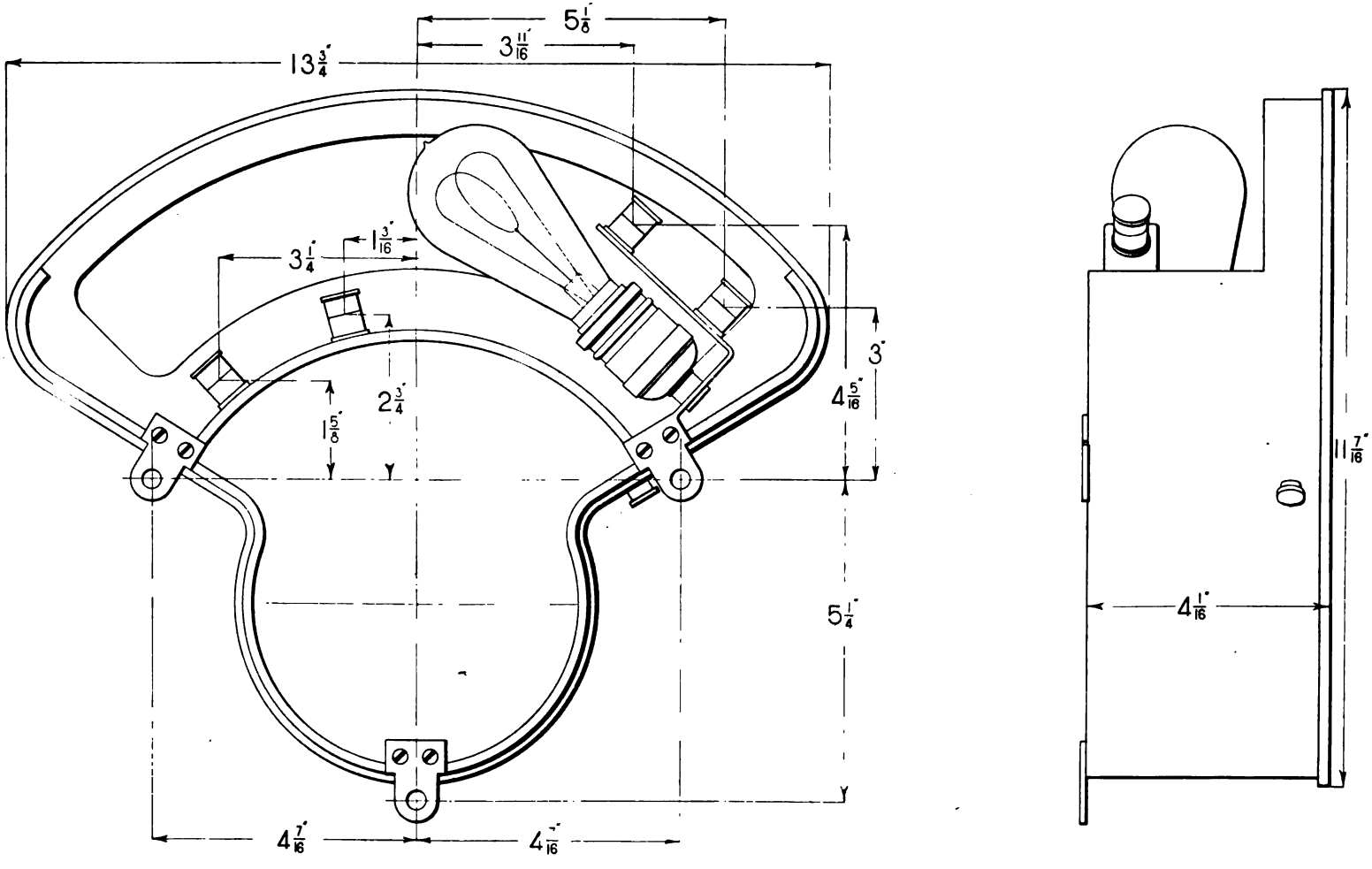
DIAGRAM OF SWITCHBOARD
Ammeter Shunts



Amperes	A	B	C	D	E	F	G	H
1500	10″	6¼″	7″	1″	3″	1¾″	6″	3¼″
2000	10″	6¼″	7″	1″	3″	1⅞″	6″	3¼″
2500	10″	6¼″	7″	1″	3″	2 ″	6″	3¼″
3000	10″	6¼″	7″	1″	3″	2⅛″	6″	3¼″
3500	10″	6¼″	7″	1″	3″	2¼″	6″	3¼″
4000	10″	6¼″	7″	1″	3″	2⅜″	6″	3¼″
4500	10″	6¼″	7″	1″	3″	2½″	6″	3¼″
5000	10″	6¼″	7″	1″	3″	2⅝″	6″	3¼″

DIMENSIONAL DIAGRAMS

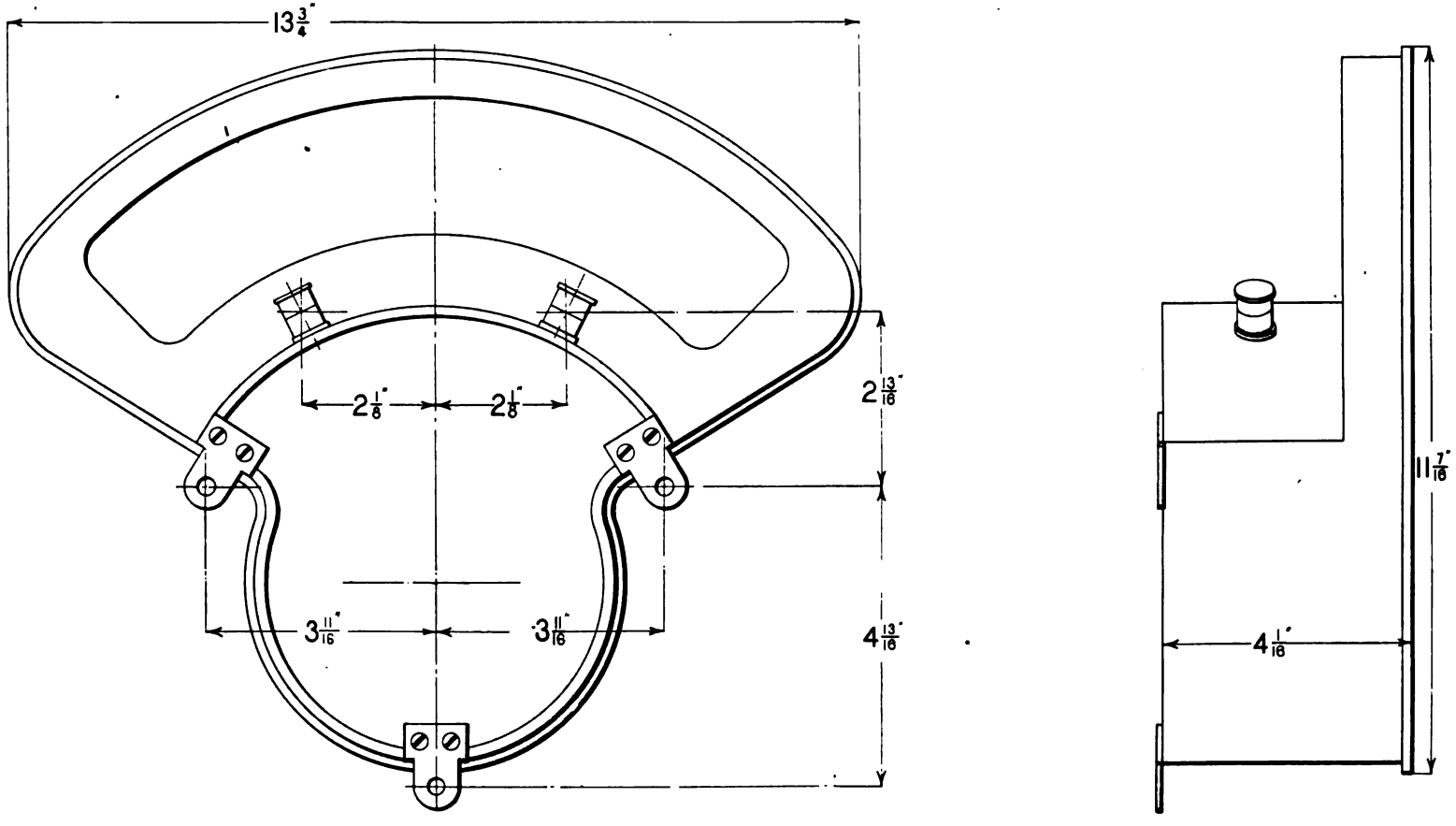
Type K Illuminated Dial Voltmeter and Shunt Ammeter



The above instruments are also made in Flush Types

DIMENSIONAL DIAGRAMS

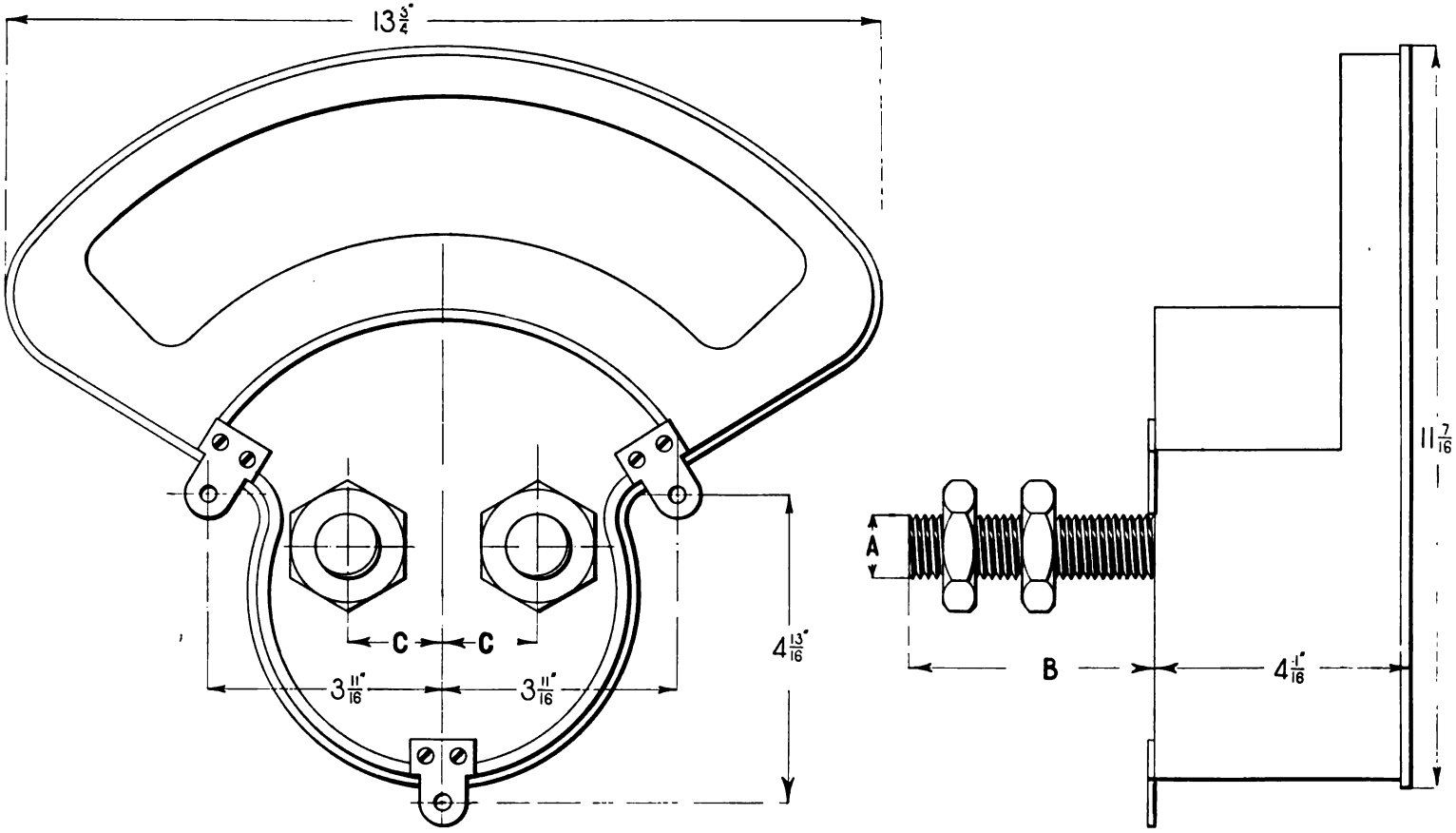
Type K Voltmeter and Shunt Ammeter



The above instruments are also made in Flush Types

DIMENSIONAL DIAGRAMS

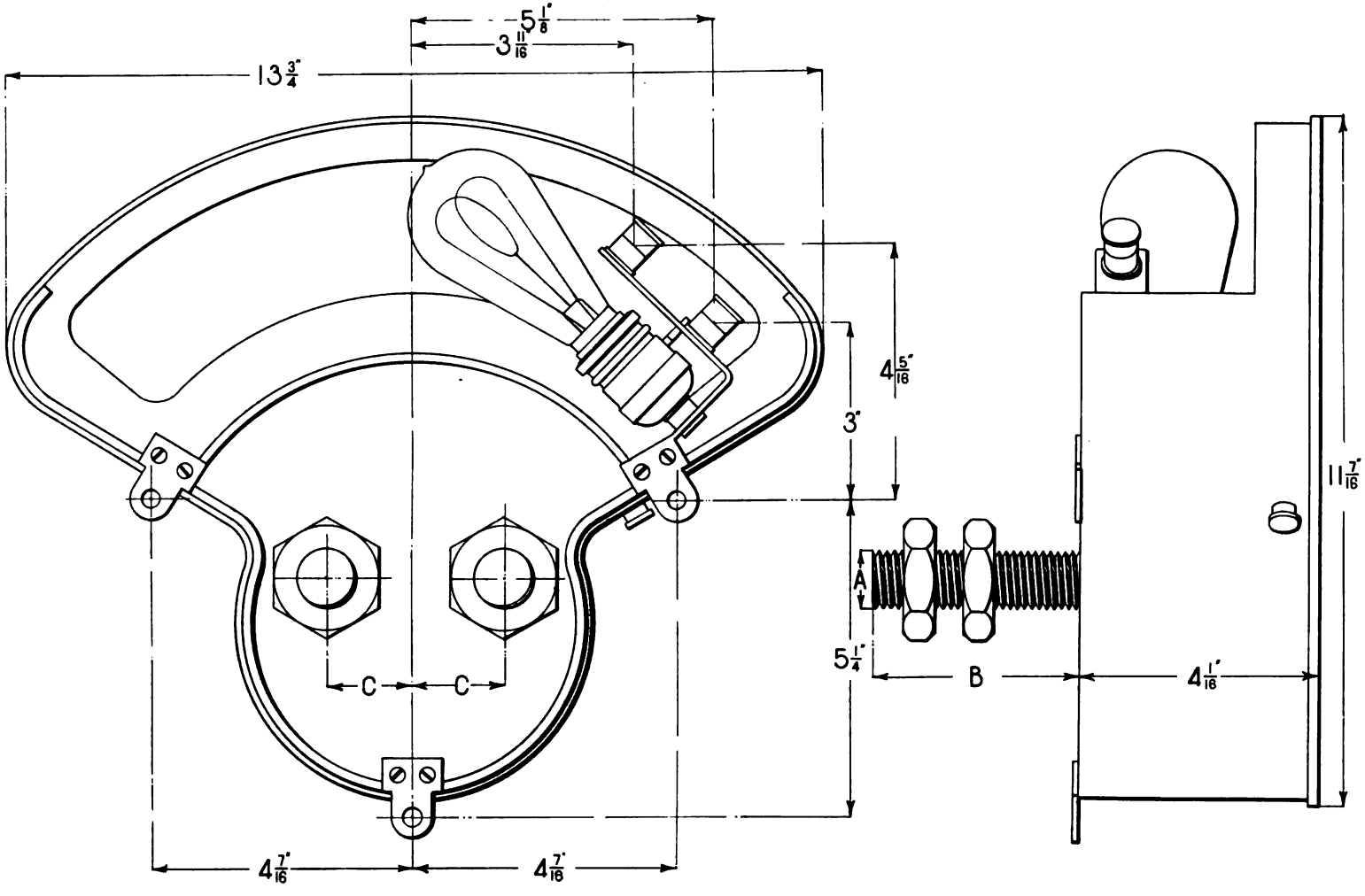
Type K Series Ammeter



The above instruments are also made in Flush Types

DIMENSIONAL DIAGRAMS

Type K Illuminated Dial Series Ammeter



The above instruments are also made in Flush Types

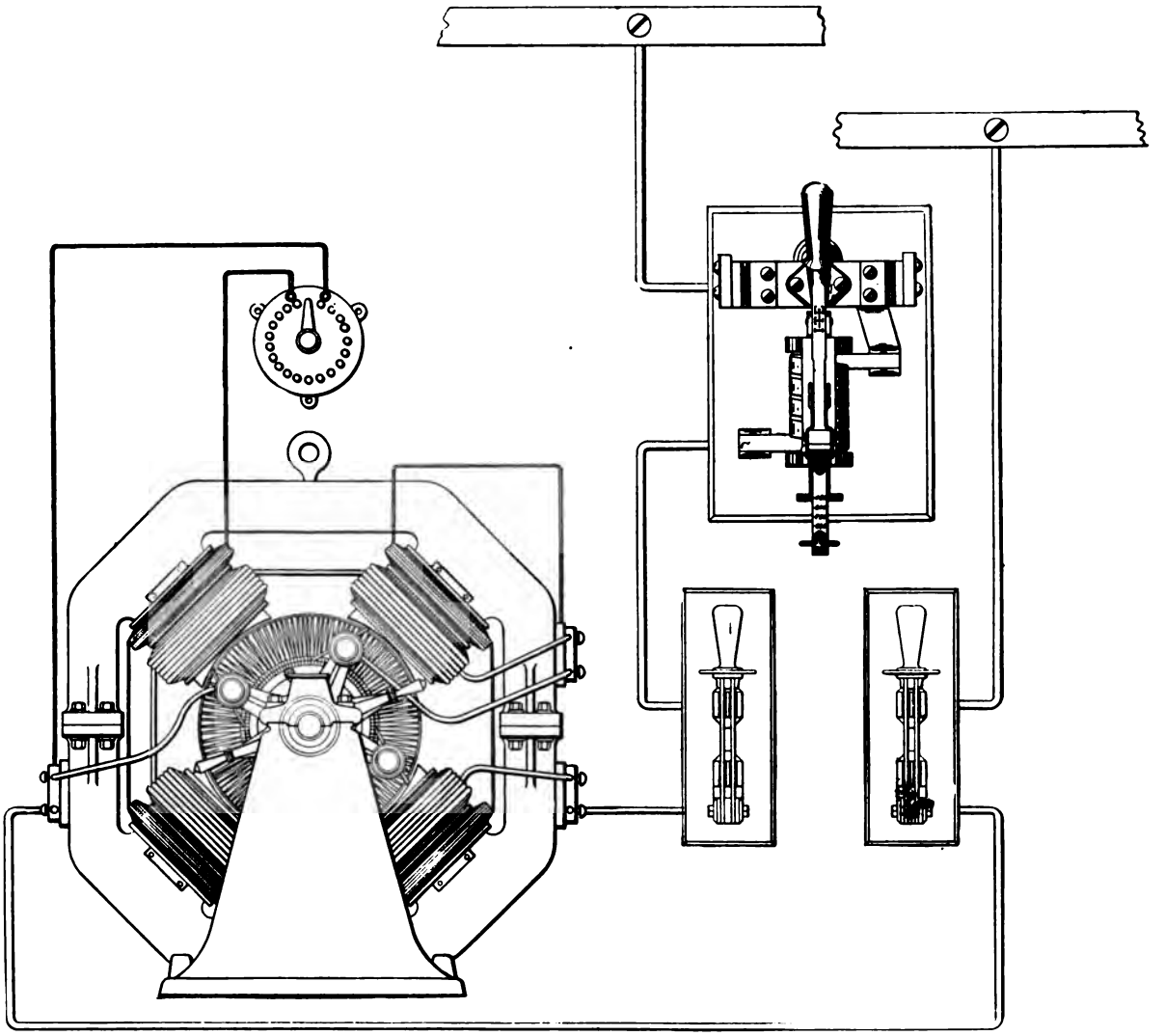
DIMENSIONS OF AMMETER TERMINALS

For Series Connected Ammeters.

Range of Instrument in Amperes	Type 'K' III. Dial. Type 'K' and Type 'R' Series Ammeters			Current Indicators		
	A	B	C	A	B	C
5	7/16"	2 7/8"	1"			
10	5/16"	2 7/8"	1"			
15	5/16"	2 7/8"	1"			
25	5/16"	2 7/8"	1"	5/16"	3 3/8"	1"
50	5/16"	2 7/8"	1"	5/16"	3 3/8"	1"
75	1/2"	3 1/8"	1"	1/2"	3 5/8"	1"
100	1/2"	3 1/8"	1"	1/2"	3 5/8"	1"
125	1/2"	3 1/8"	1"	1/2"	3 5/8"	1"
150	1/2"	3 1/8"	1"	1/2"	3 5/8"	1"
175	3/4"	3 1/4"	1"	3/4"	3 3/4"	1"
200	3/4"	3 1/4"	1"	3/4"	3 3/4"	1"
250	3/4"	3 1/4"	1"	3/4"	3 3/4"	1"
300	1"	3 15/16"	1 1/2"	1"	4 7/16"	1"
400	1"	3 15/16"	1 1/2"	1"	4 7/16"	1"
500	1"	3 15/16"	1 1/2"	1"	4 7/16"	1"
600	1"	3 15/16"	1 1/2"			
700	1 1/8"	4 3/4"	1 1/2"			
800	1 1/8"	4 3/4"	1 1/2"			
900	1 1/4"	4 7/8"	1 1/2"			
1000	1 1/4"	4 7/8"	1 1/2"			
1250	1 1/2"	5 1/4"	1 1/2"			
1500	1 1/2"	5 1/4"	1 1/2"			
2000	1 3/4"	5 1/4"	1 1/2"			

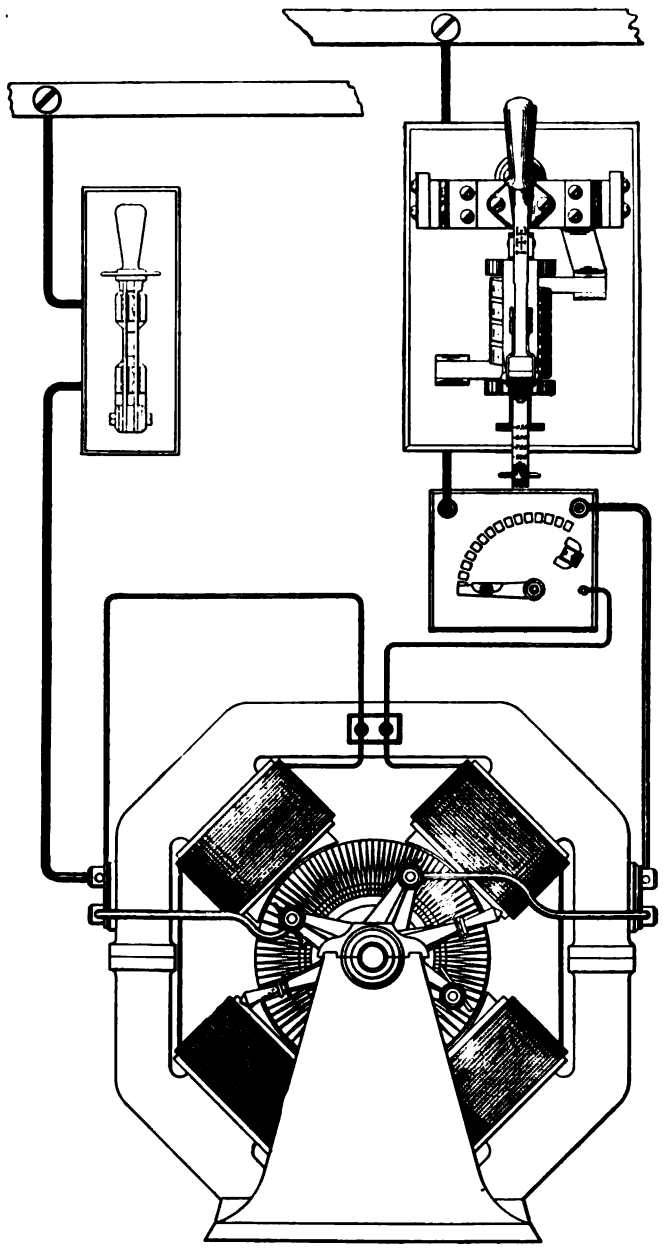
Applying to Dimensional Diagrams of Switchboad Series Ammeters.

This and the following diagrams serve to suggest methods of connecting I-T-E Circuit Breakers, to meet a number of the most usual conditions of service.



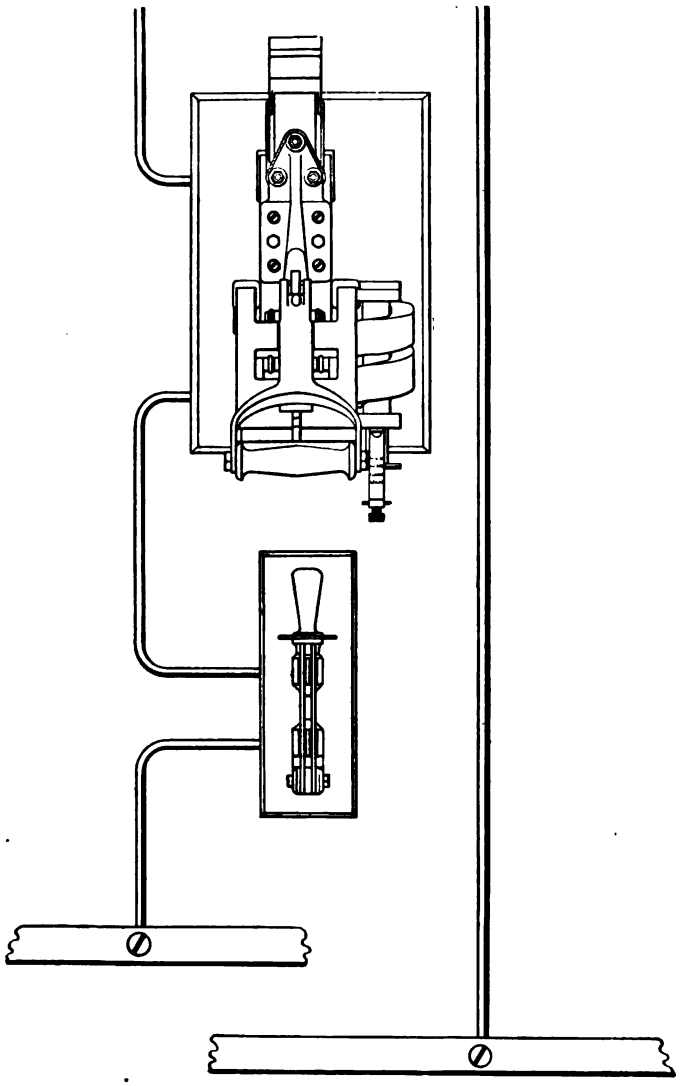
Connections of Single Pole I-T-E Overload Circuit Breaker

Arranged to protect Generator. See pages 12 and 16 of catalogue



Connections of Single Pole I-T-E Overload Circuit Breaker

Arranged to protect Motor. See pages 12 and 16 of catalogue

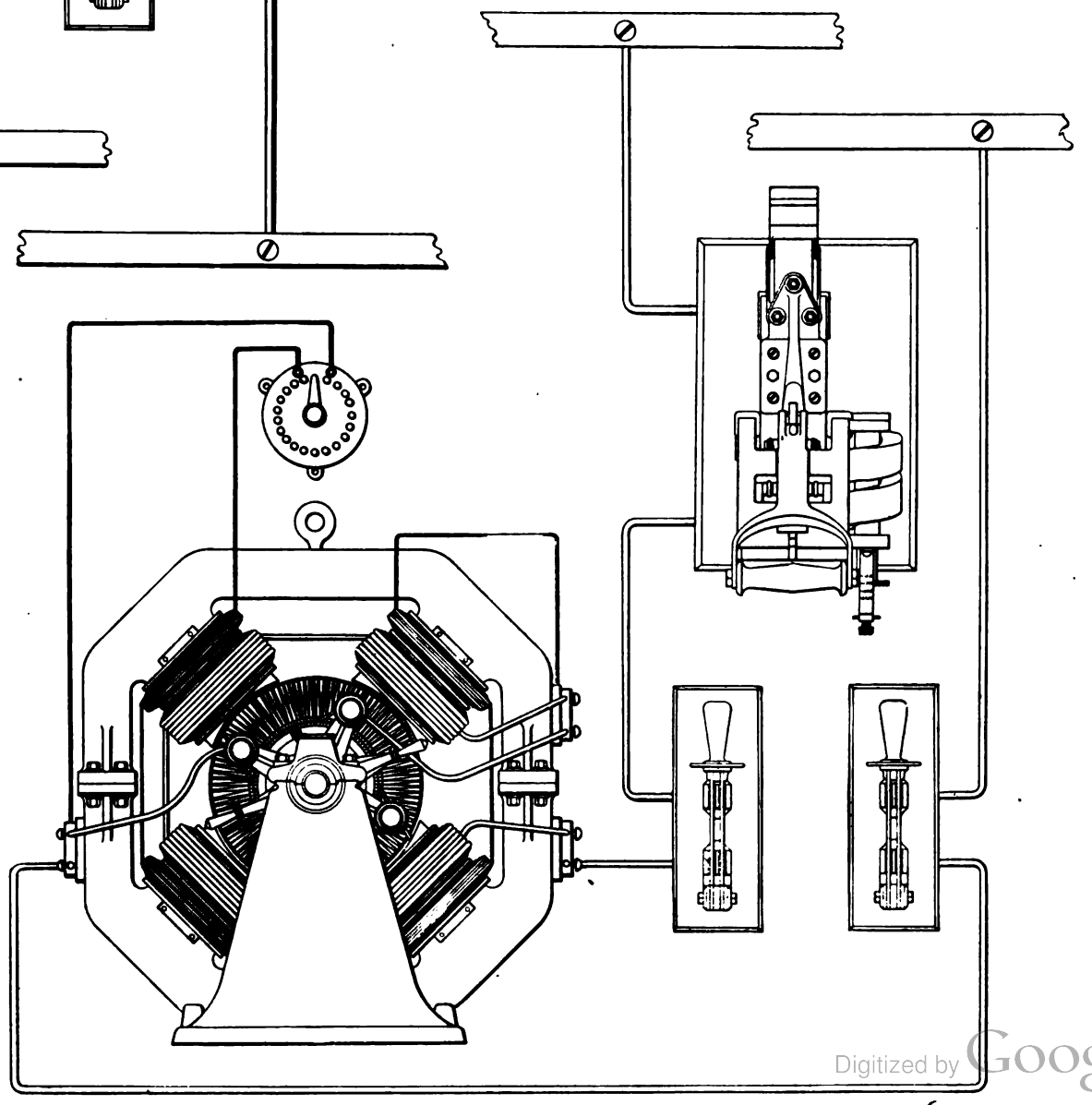


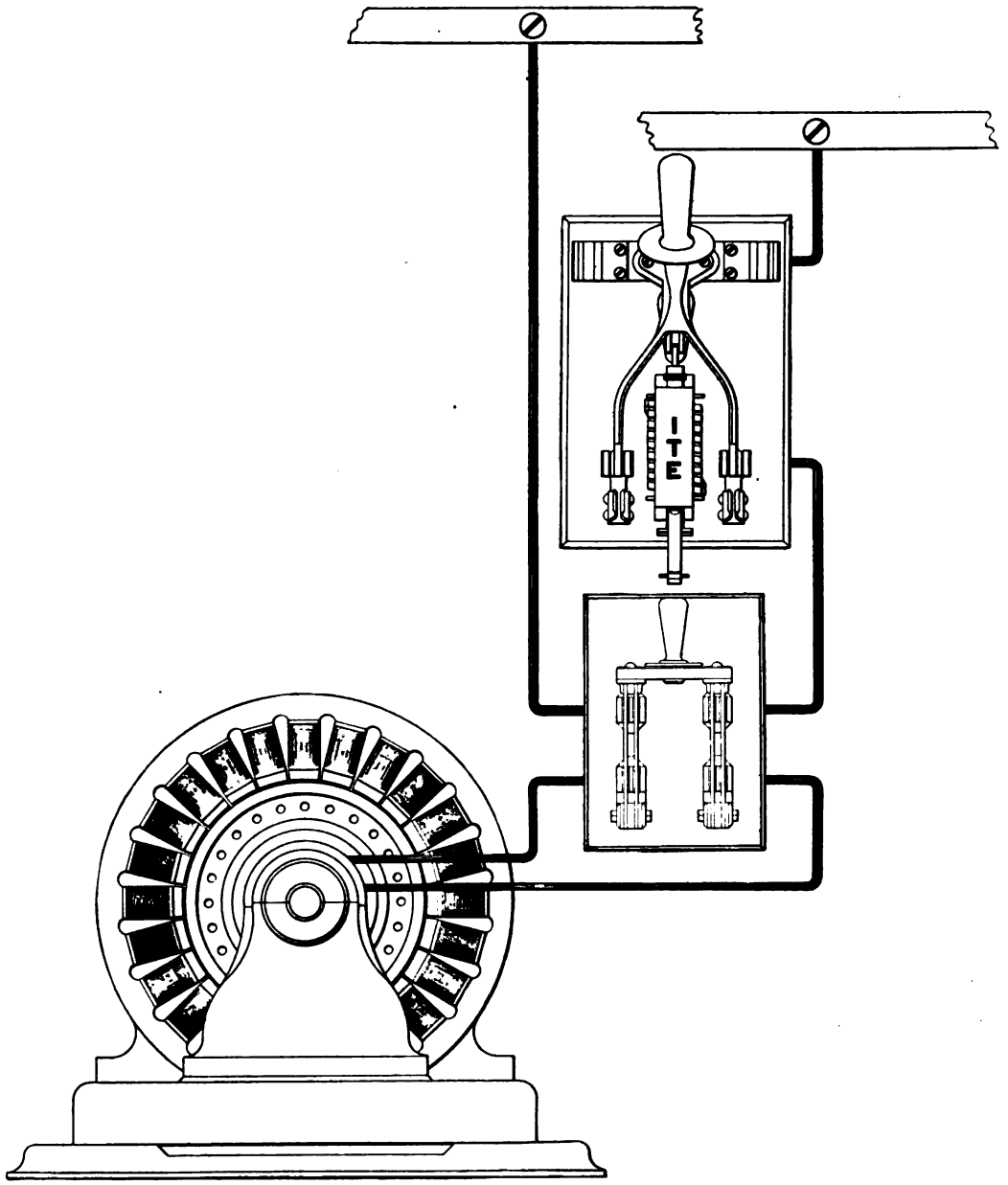
Single Pole I-T-E Overload Circuit Breaker—Laminated Type

Connected in feeder circuit. See pages 126 and 142 of catalogue.

Single Pole I-T-E Overload Circuit Breaker—Laminated Type

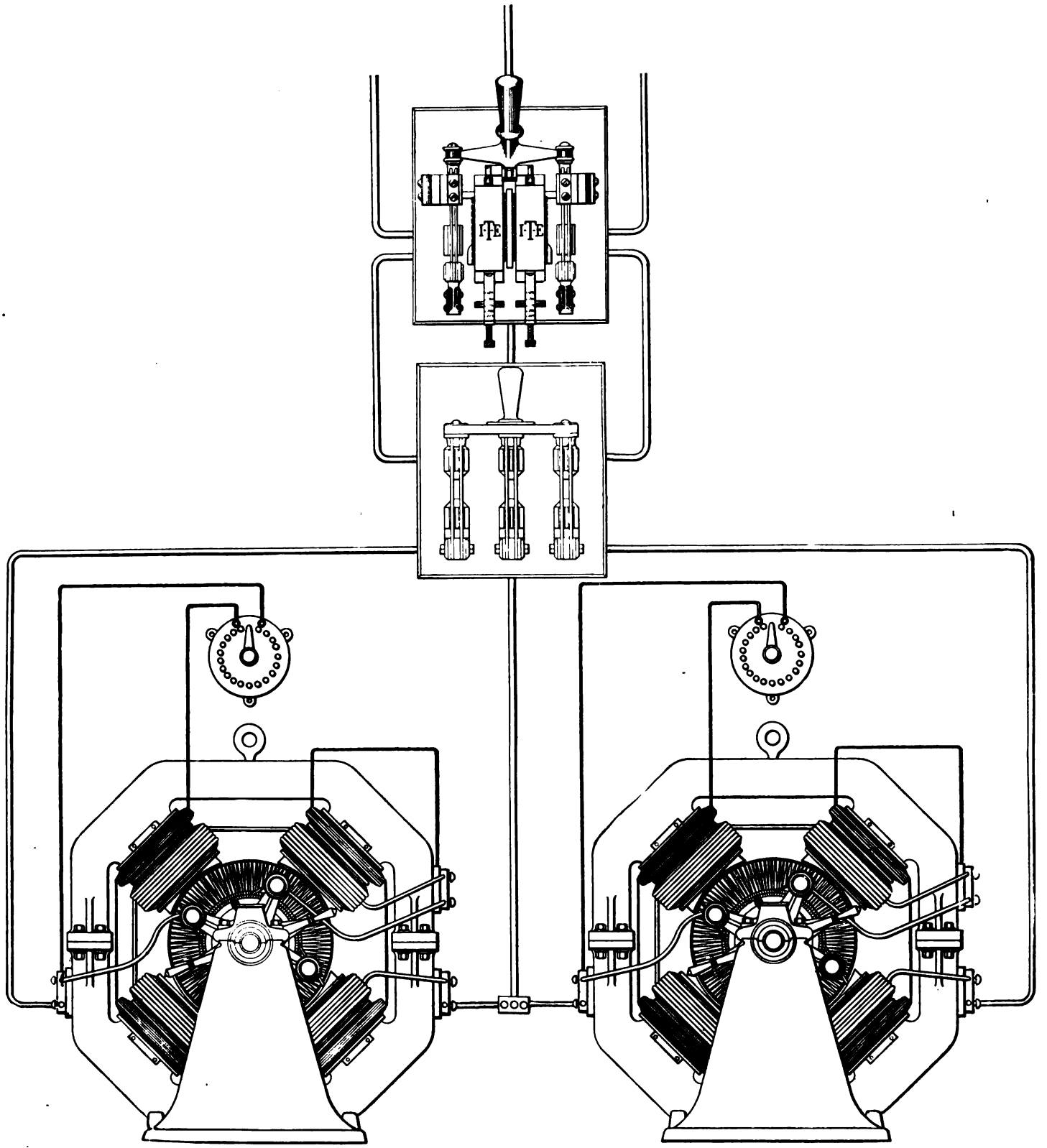
Connected to protect generator. See pages 126 and 142 of catalogue.





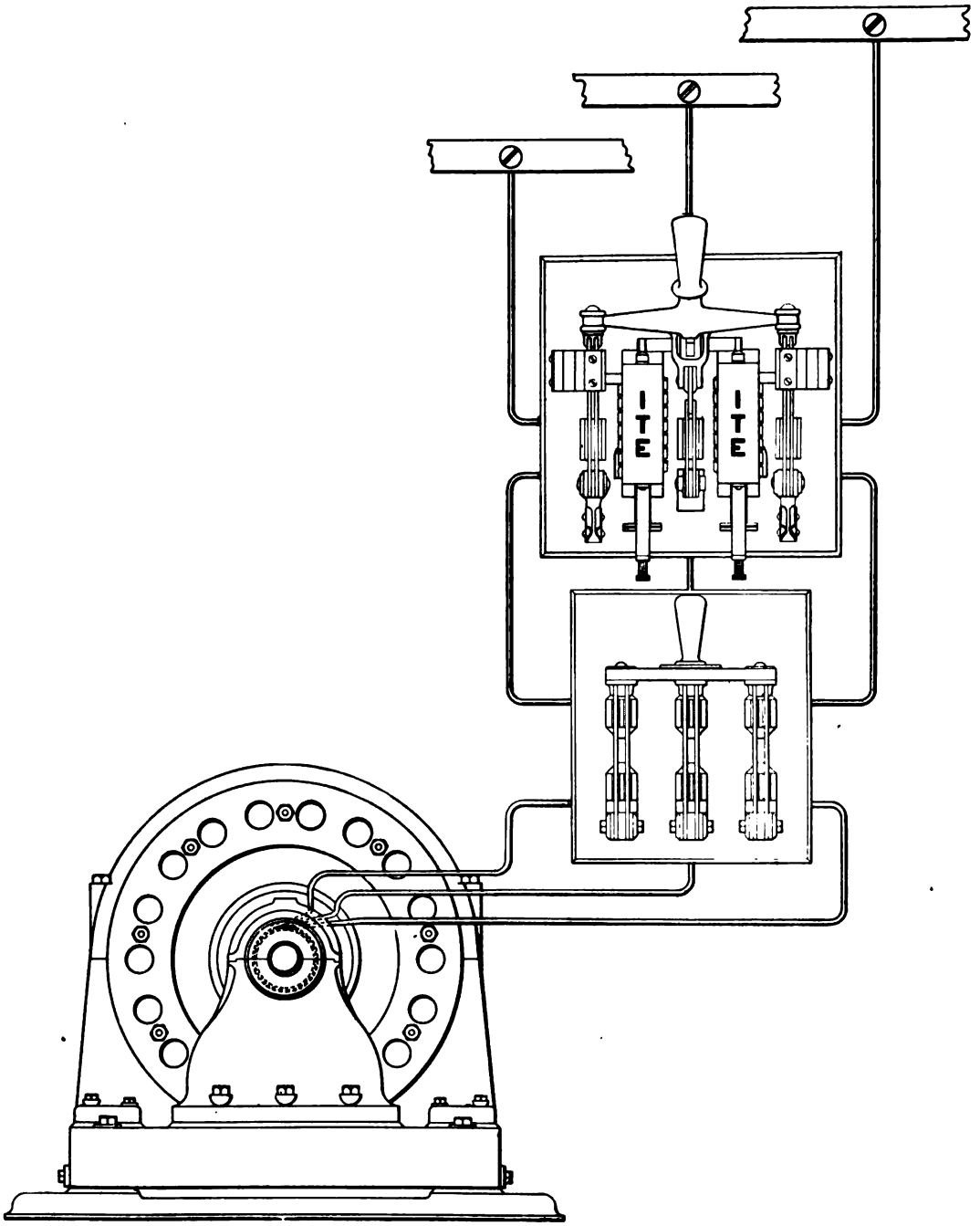
Single Pole I-T-E Circuit Breaker

Connected to protect single phase alternating current generator. See page 35 of catalogue.



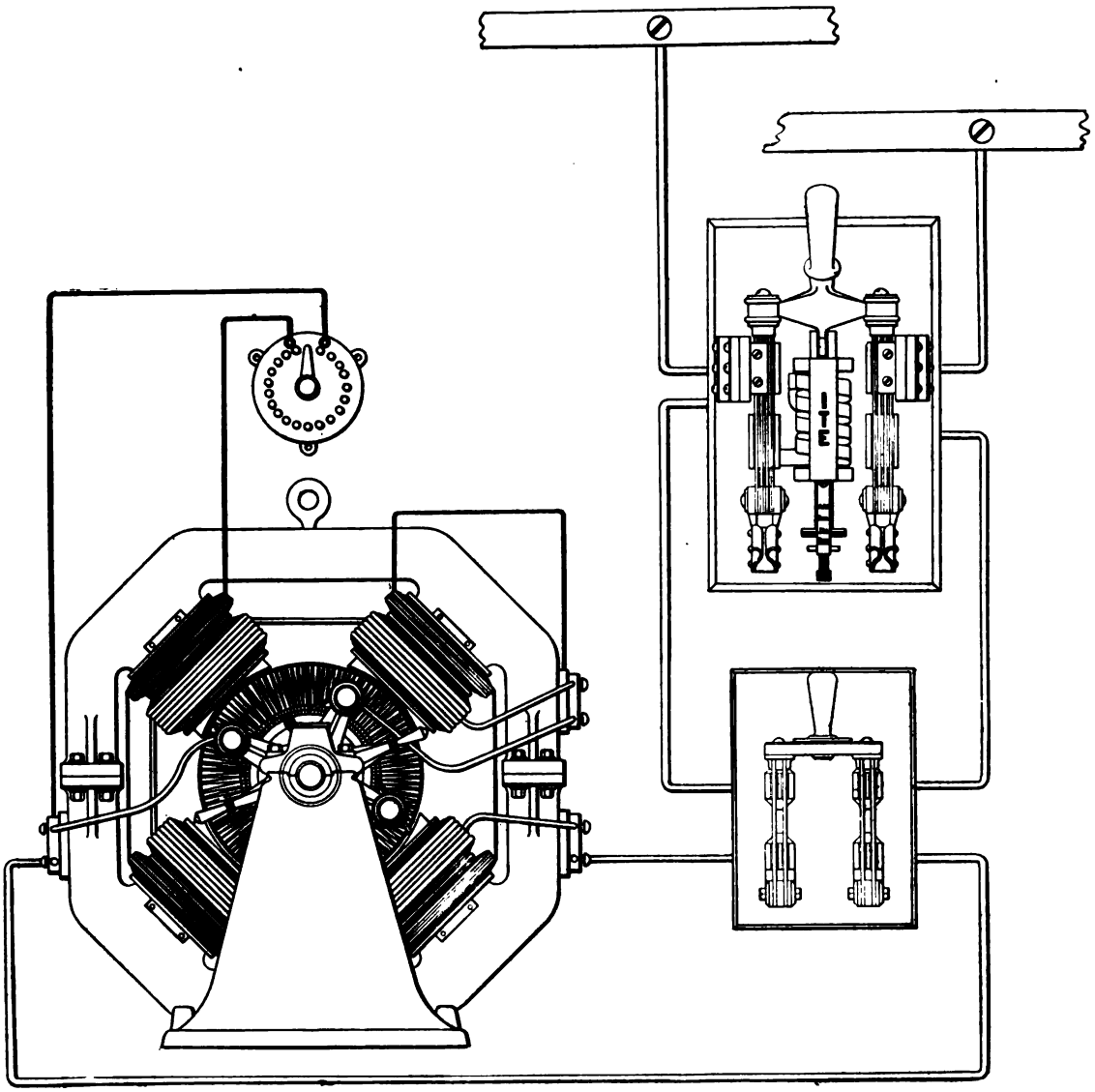
Connections of Double Pole Two-Coil I-T-E Circuit Breaker

Arranged for the protection of generators on Edison Three-Wire System. See pages 44 and 46 of catalogue, also pages 122, 136 and 138, for Laminated Types.



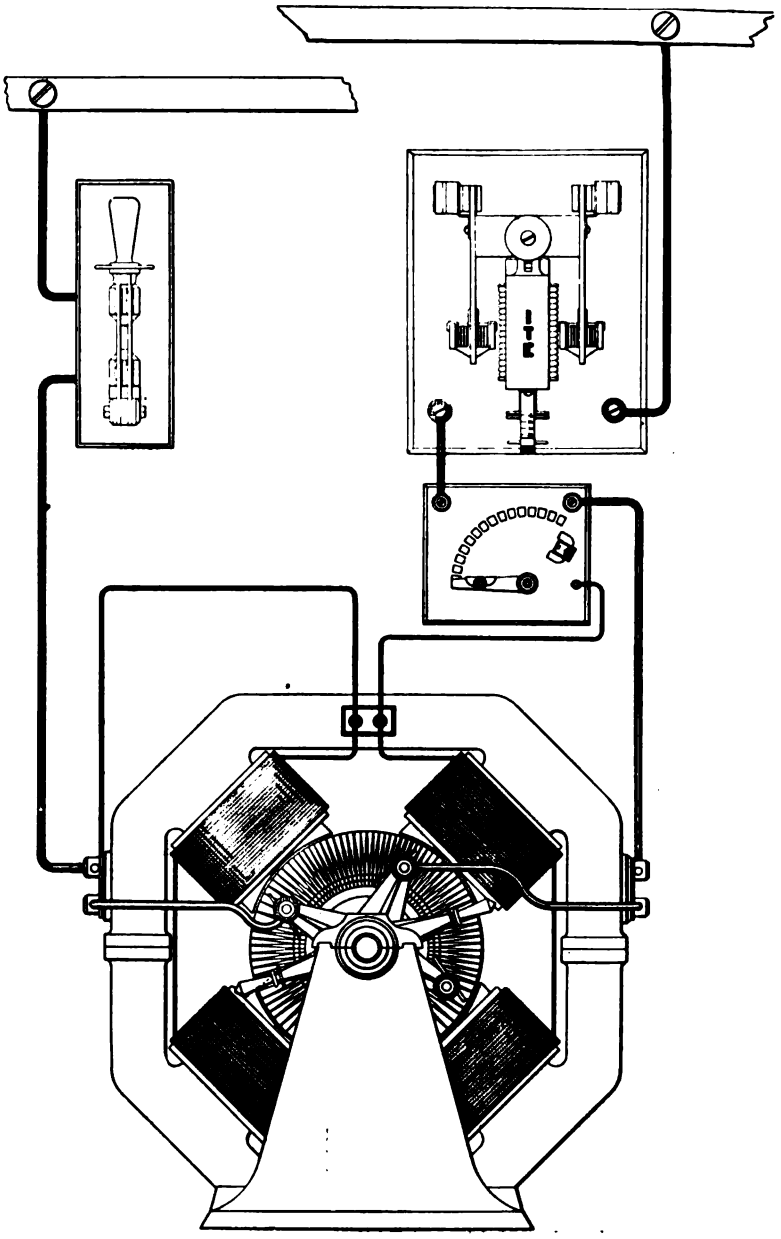
Connections of Three Pole Two-Coil I-T-E Circuit Breaker

Arranged for the protection of three-phase alternating current generator. See page 48 of catalogue, also pages 124 and 140 for Laminated Types.



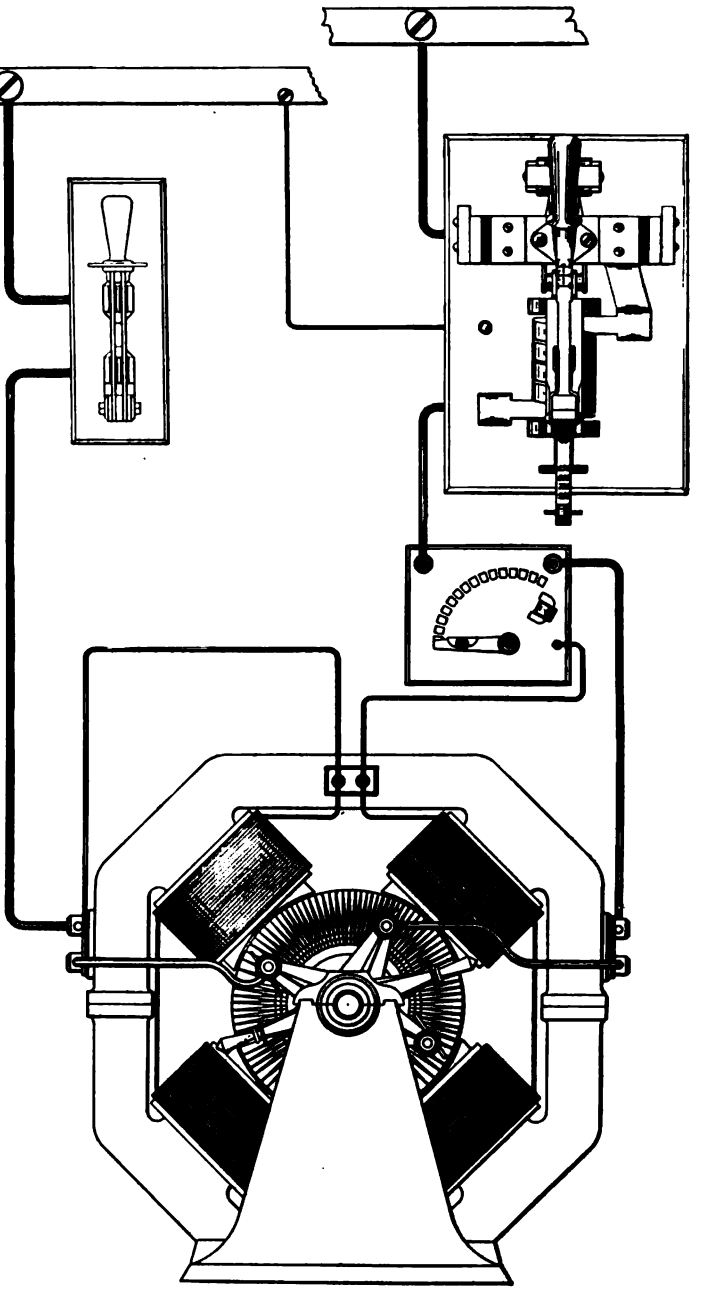
Connections of Double Pole I-T-E Overload Circuit Breaker

For the protection of generator. See pages 26 and 30 of catalogue, also 118, 128, 130 and 144, for Laminated Types.



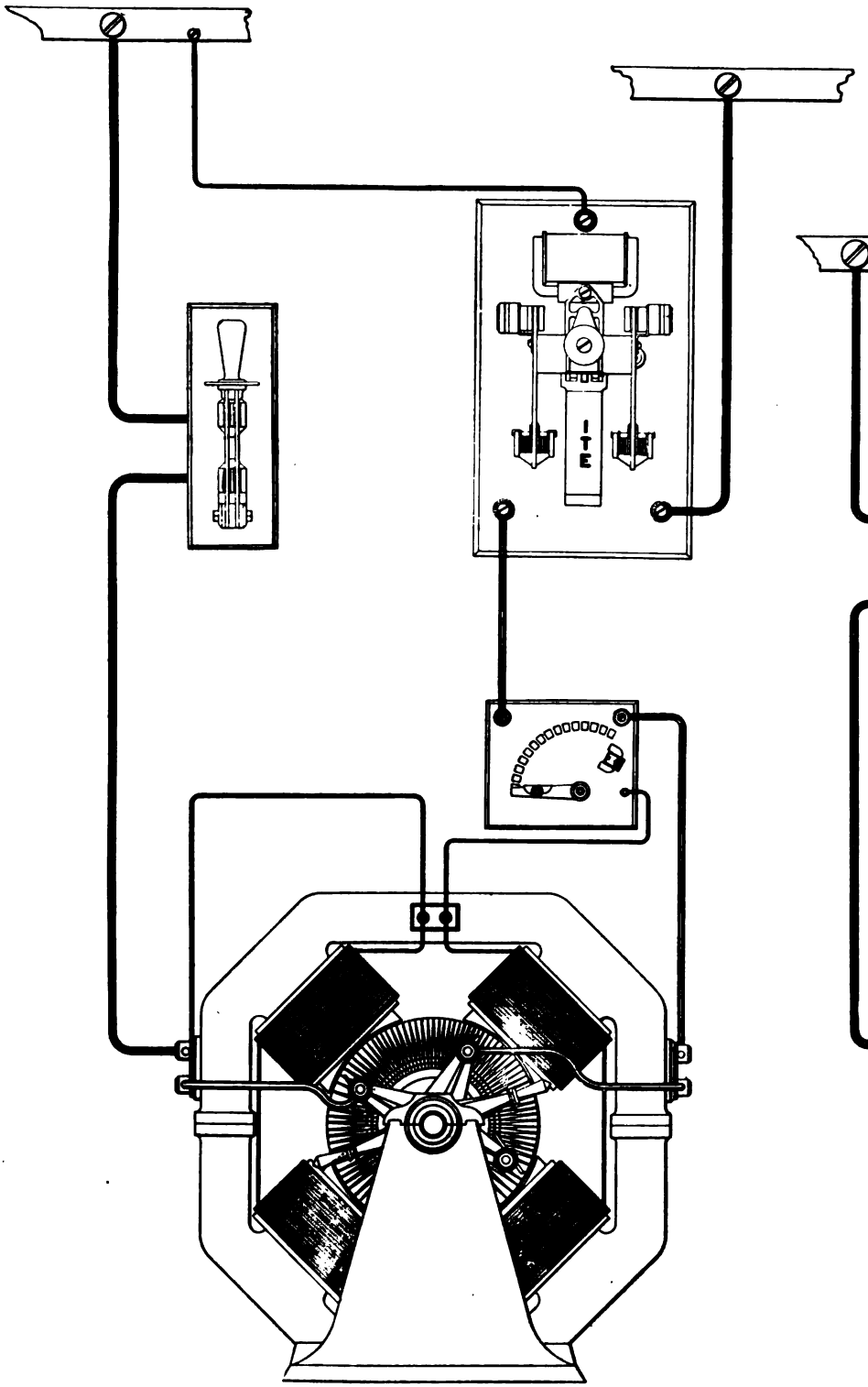
Connections of Single Pole I-T-E Circuit Breaker (Midget Junior Type)

For the protection of motor from overloads. See pages 8 and 10 of catalogue.



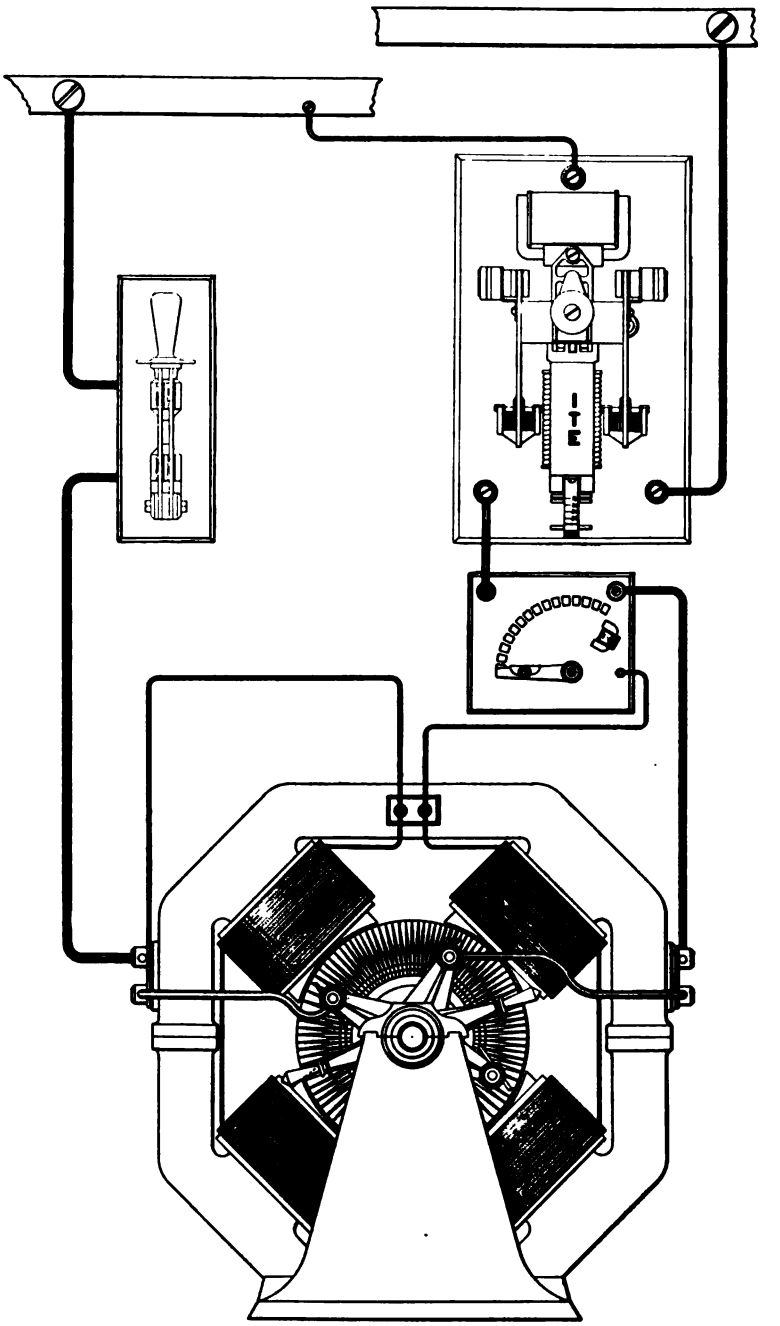
Connections of Single Pole Overload and No Voltage I-T-E Circuit Breaker

For Protecting motor from overloads, also disconnecting the motor in case of failure of line pressure. See pages 84, 86, 88 and 90 of catalogue.



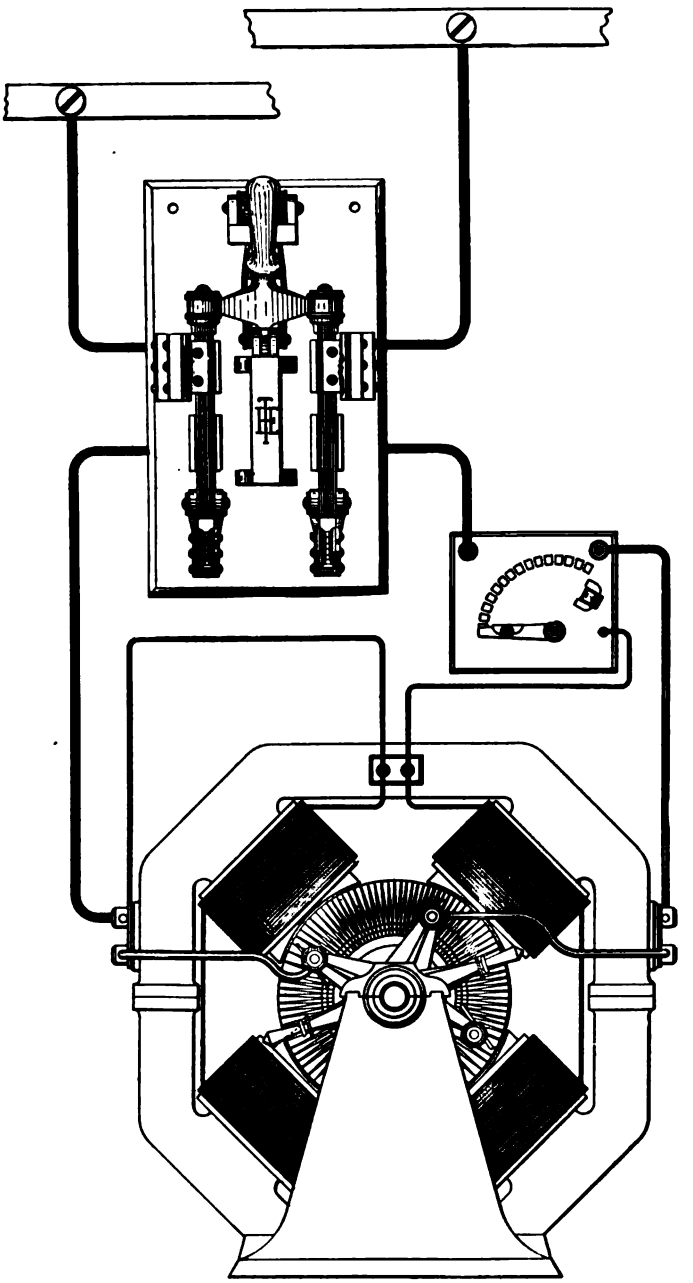
Connections of Single Pole I-T-E No Voltage Circuit Breaker (Midget Junior Type)

Arranged to disconnect motor upon failure of line pressure. See pages 50 and 52 of catalogue.



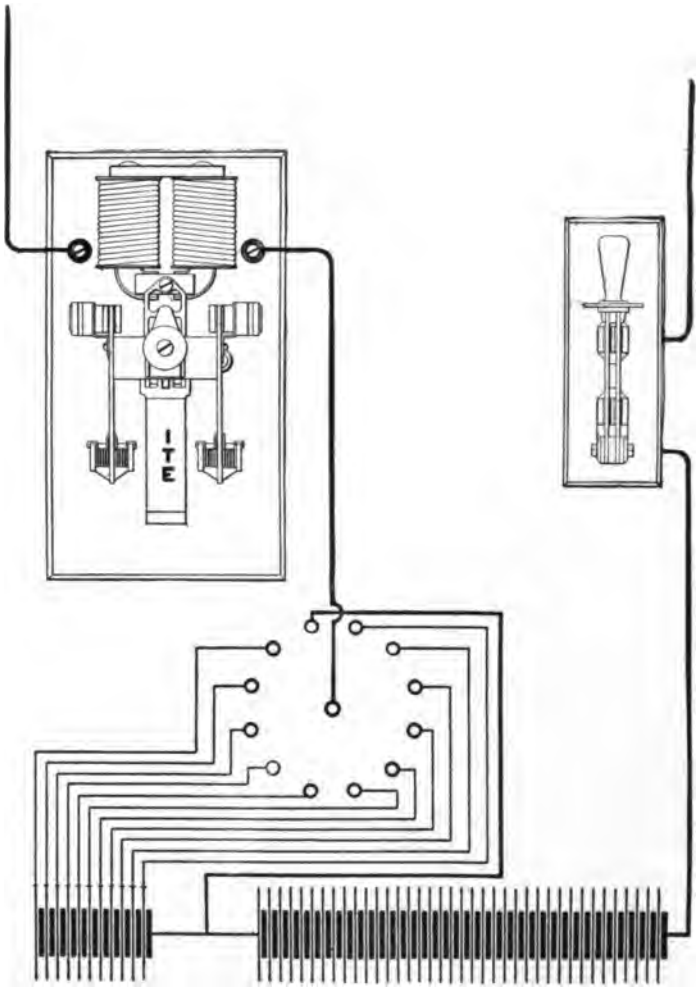
Connections of Single Pole I-T-E Overload and No Voltage Circuit Breaker (Midget Junior Type)

Arranged to protect motor from overloads, also to disconnect it in case of failure of line pressure. See pages 80 and 82 of catalogue.



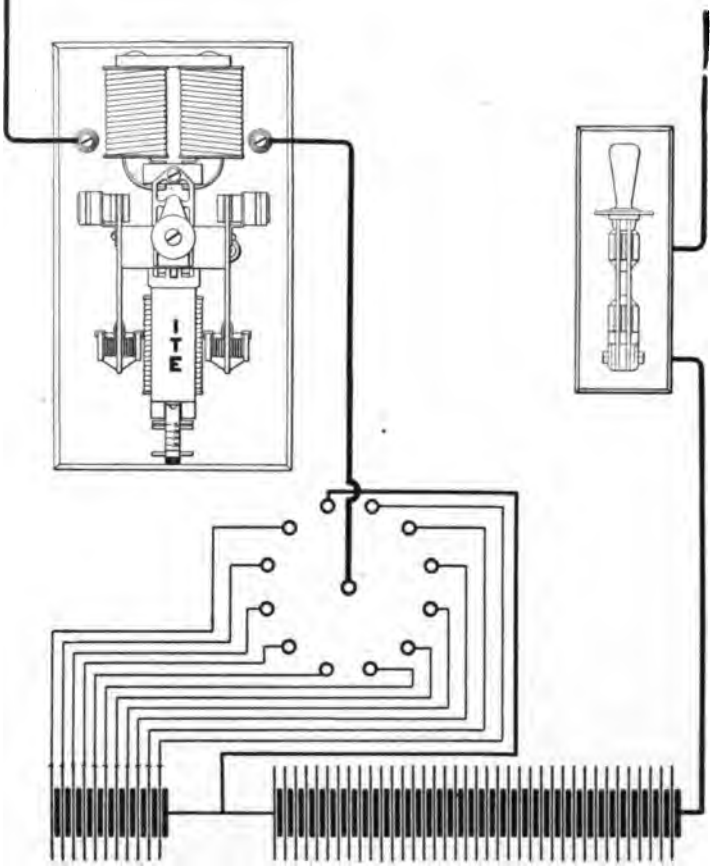
Connections of Double Pole I-T-E Circuit Breaker (No Voltage Type)

Arranged to disconnect both poles of motor upon failure of line pressure. See pages 64 and 66 of catalogue.



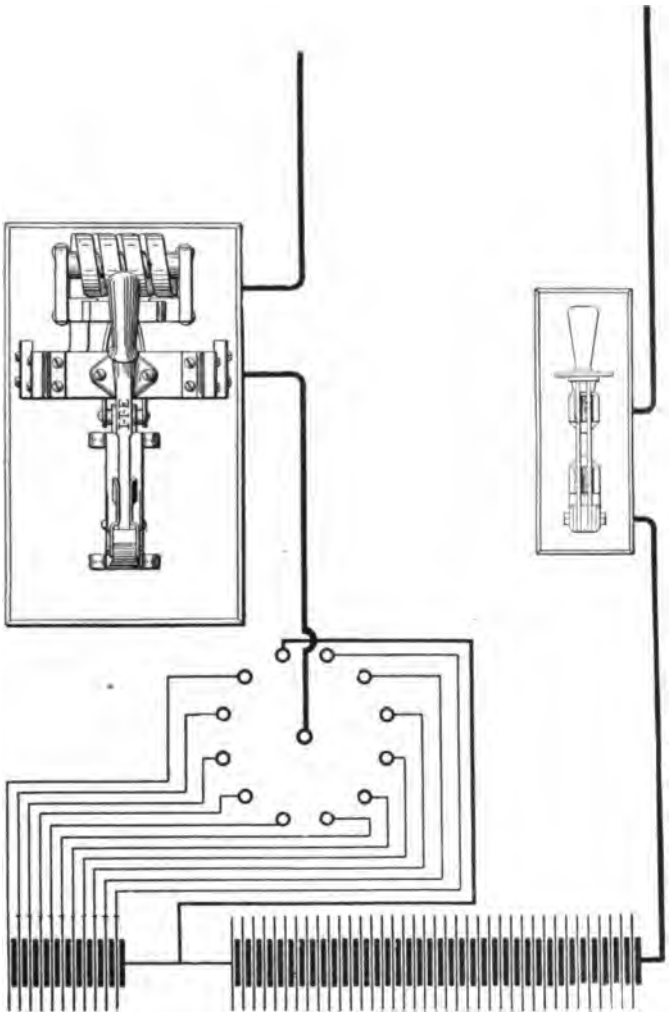
Connections of Single Pole I-T-E Underload Circuit Breaker (Midget Junior Type)

Arranged to disconnect storage battery when same is fully charged or tends to reverse into charging line. See page 68 of catalogue.



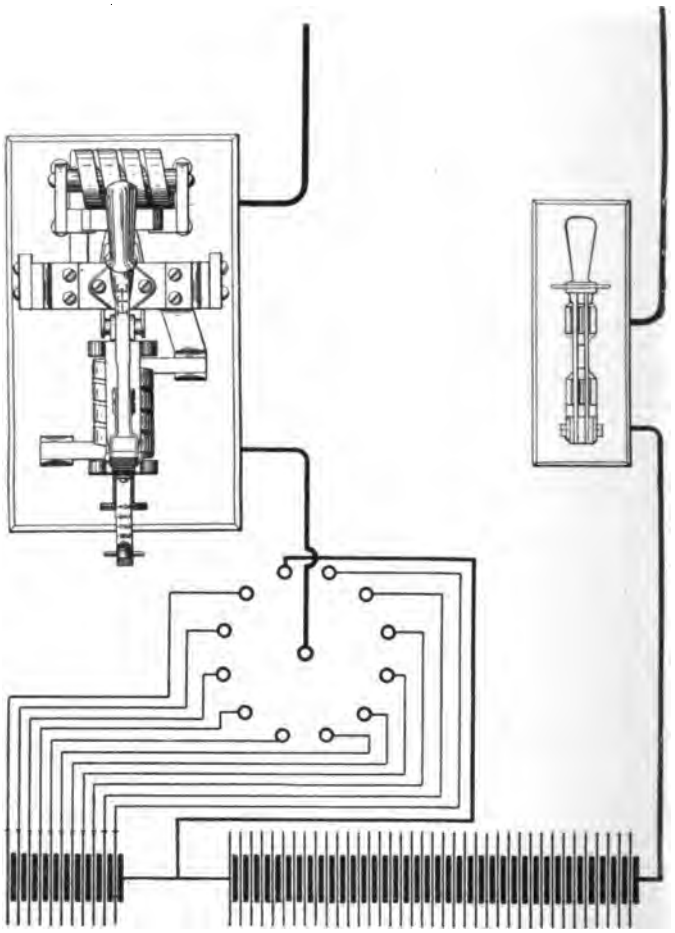
Connections of Single Pole I-T-E Overload and Underload Circuit Breaker (Midget Junior Type)

Arranged to disconnect storage battery upon the passage of excessive current, also when the same is fully charged or tends to reverse into charging line. See page 98 of catalogue.



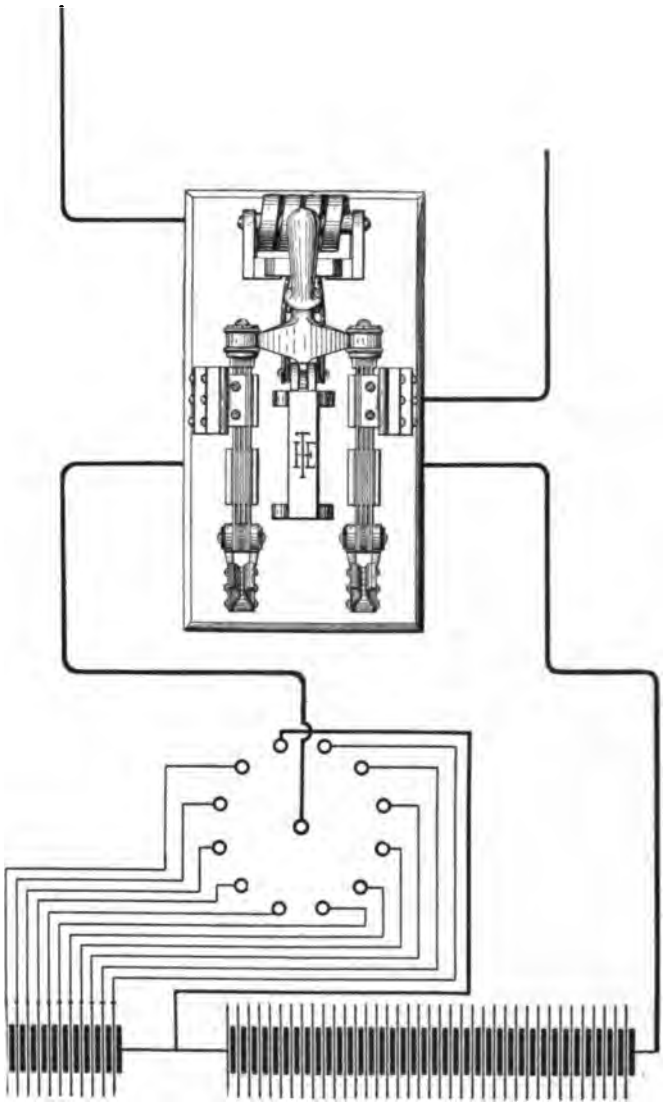
Connections of Single Pole I-T-E Underload Circuit Breaker

Will disconnect storage battery when fully charged, or when it tends to reverse into the charging line. See pages 70 and 72 of catalogue.



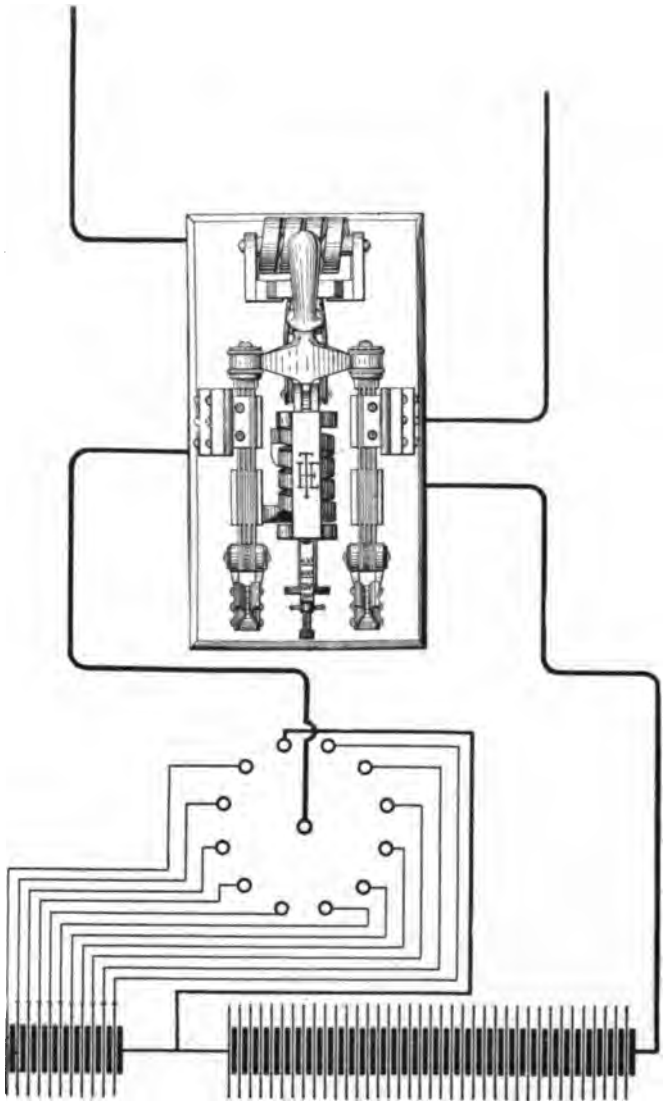
Connections of Single Pole I-T-E Overload and Underload Circuit Breaker

Arranged to disconnect storage battery upon the passage of excessive current, also when fully charged, or when the battery current tends to reverse into the charging line. See pages 100, 102 and 104 of catalogue.



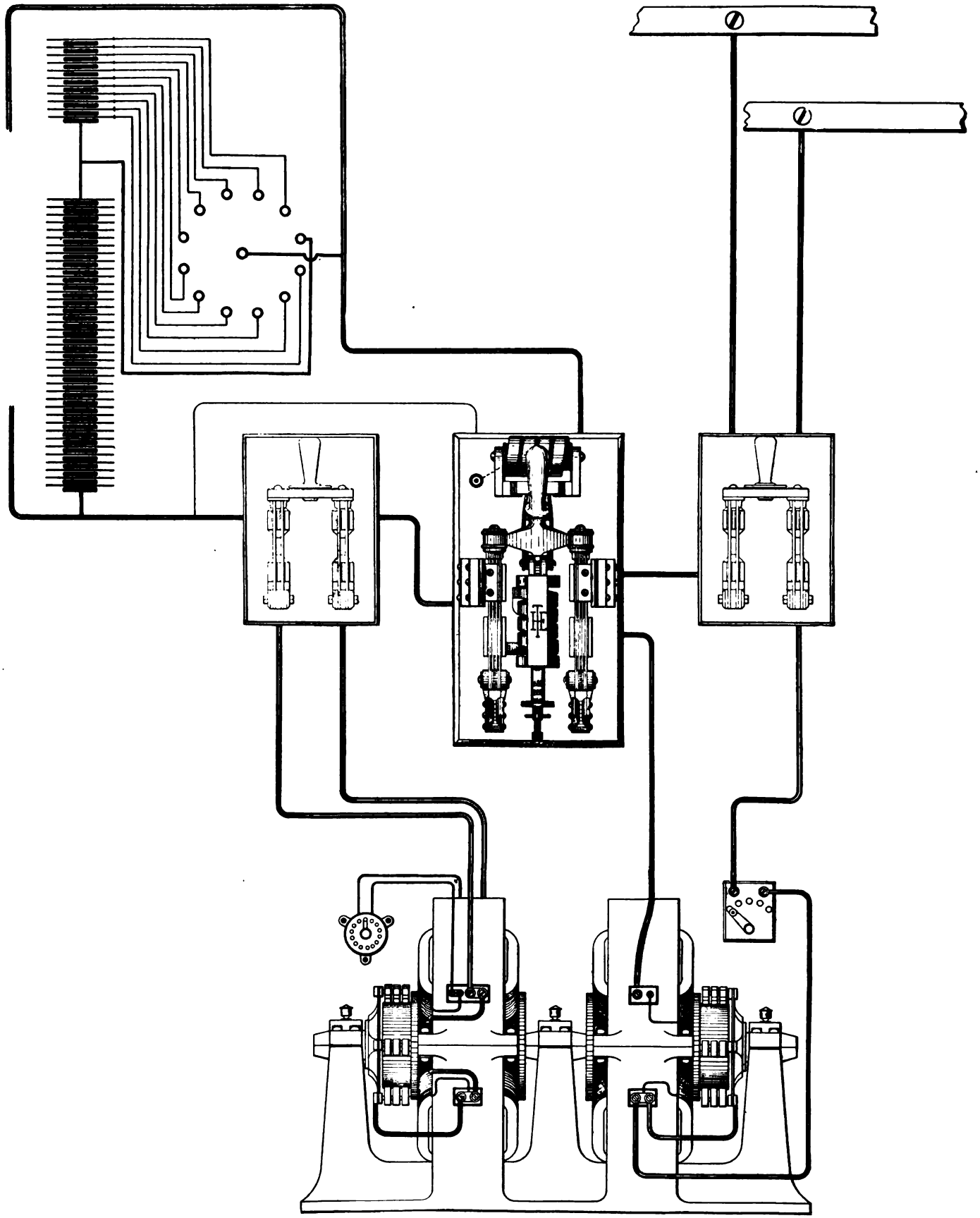
Double Pole I-T-E Underload Circuit Breaker

Arranged to disconnect storage battery when same is fully charged, or when it tends to reverse into the charging line. See pages 76 and 78 of catalogue.



Double Pole I-T-E Overload and Underload Circuit Breaker

Arranged to protect storage battery from the passage of excessive currents, also to disconnect it when fully charged, or when it tends to reverse into the charging line. See pages 108 and 110 of catalogue.



Double Pole Overload and Reversal Type I-T-E Circuit Breaker

Arranged for the protection of motor generating set employed to charge storage battery. Disconnects both motor and generator, either in the event of overload or in the event of failure of the current supply. The Circuit Breaker shown is equally satisfactory whether the motor current is direct or alternating. It is one of our many "Specials."

SWITCHBOARDS
FOR STREET RAILWAY WORK

Perhaps no feature of an electrical installation contributes more to its efficiency than a properly designed and carefully constructed switchboard, while on the other hand, imperfections at this point may render unsatisfactory an equipment otherwise perfect; for this reason the switchboard well deserves the careful attention devoted to it by the progressive engineer. The recent developments in switchboard practice have all been along the line of increased simplicity; unnecessary complications have been eliminated, oftentimes at some sacrifice of flexibility. In present-day practice usefulness is aimed for rather than extreme ornamentation, and neatness, uniformity and simplicity are sought even to the point of plainness of appearance. To sum up, the essential features of switchboard design are simplicity, uniformity, effectiveness in operation and convenience of manipulation. While these points are important elements in any switchboard construction, they are particularly so in the case of street railway work, where the conditions to be met with are among the most severe, and where emergencies are constantly arising, which, if

Illustration No. 44
Standard Generator Panel
For Standard Railway Switchboard

Illustration No. 45
Standard Feeder Panel
for
Street Railway Switchboard

not instantly and effectively dealt with, will inevitably lead to serious results.

It must be remembered that all of the many different feeders which leave the street railway switchboard are at the mercy, not only of the elements, but of fires and accidents which are liable to occur within the area which they cover, and in the majority of instances the excessive conditions thus thrown upon the generators at the station must be cared for by the apparatus upon the switchboard, which therefore must be selected with a view to meeting these abnormal conditions as well as those of ordinary operation.

With these considerations in mind, it is obvious that the switchboard appliances should be chosen with a view to simplicity and reliability under any and all conditions of service, while they should be so located upon the switchboard as to be most accessible to the eye and hand of the attendant.

In the street railway switchboard, uniformity of design is a most important point, not only on the score of appearance, but also on account of the increased ease of handling which is thus attained, and greater certainty of action on the part of the switchboard attendant in the event of emergency; for where all of the panels are of one standard design, "habit" comes very materially to the aid of the operator. Again, the street railway switchboard is likely to be the subject of

frequent enlargements, and where it is composed of units conforming with a standard design, additions can be made with greatest promptness and at least expense.

While these principles apply very generally for all conditions, the choice of the type of panel for each particular case can be made only when all of the conditions of operation are known. With these in hand, the problem is a relatively simple one, as switchboard builders are always ready to submit full data and plans to meet every contingency.

We append herewith cuts of the street railway panels, for which we are indebted to a leading builder of this class of apparatus.

Cut No. 44 represents the Standard Generator Panel, provided with I-T-E Laminated Type Circuit Breaker, mounted at the top where the flash incident upon breaking the circuit can occasion no damage. The amply proportioned spade handle, closing the instrument by easy downward movement, makes its manual operation extremely simple regardless of position. Next below is the ammeter, situated so as to be about on a level with the eye; a suitably located incandescent lamp and reflector makes the scale readable, even at a distance; below, to the left, is shown the shunt field switch, across the contacts of which is connected a non-inductive resistance, in series with which

Illustration No. 46
Total Output Panel
For Street Railway Switchboard

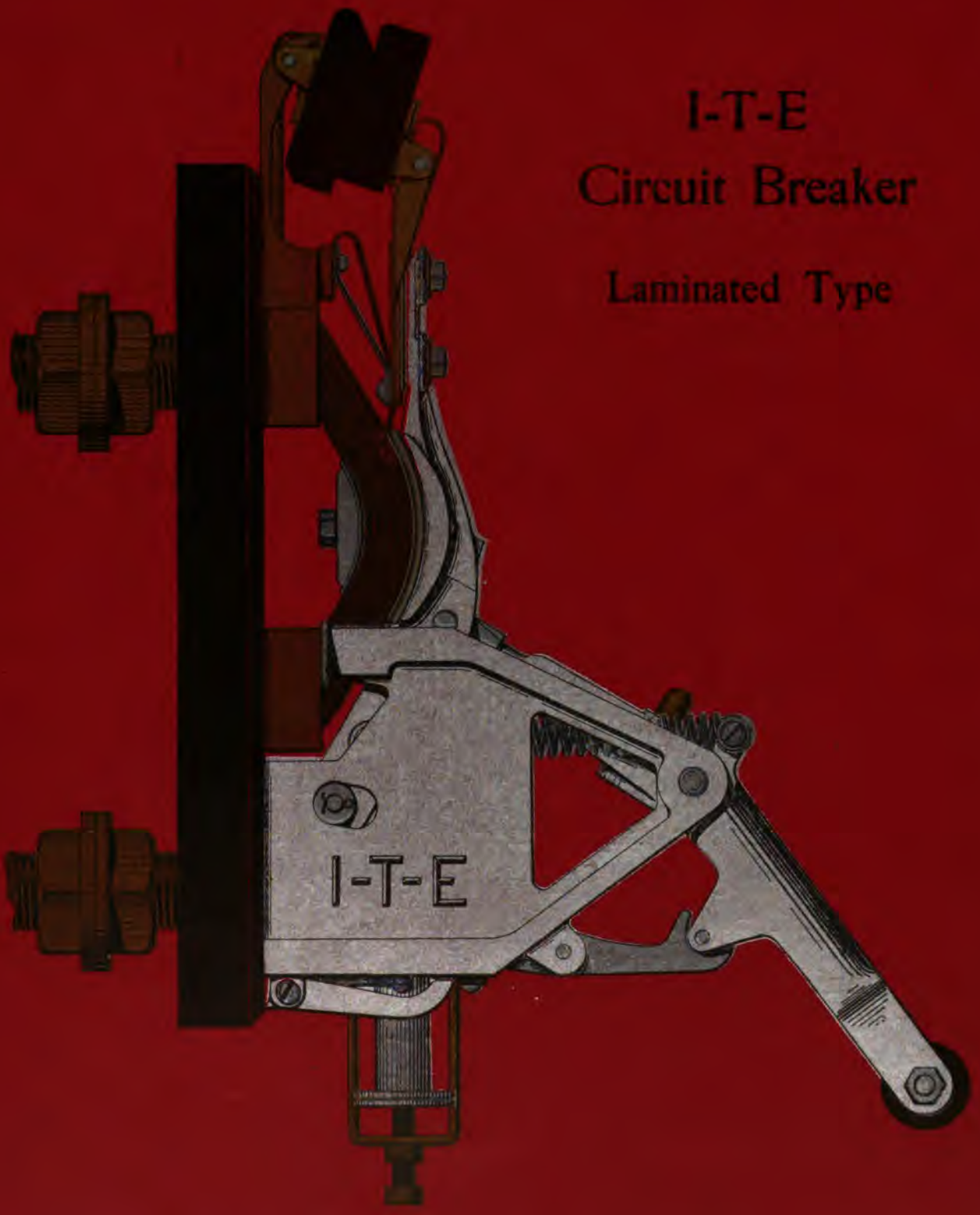
is the pilot lamp placed upon the front of the panel. The resistance shunts the field at break and serves to take up the inductive discharge; the pilot lamp, lighting up as it does on the occasion of each break, indicates that the shunt has been properly brought into circuit.

Illustration No. 47

The voltmeter switch, directly below the field switch, enables the station voltmeter to be thrown from the circuit of one generator to another. The one shown here is of the familiar plug type

I-T-E
Circuit Breaker

Laminated Type



THE illustration shown on the opposite side is a unit out of which is built the

"DUBLARM"

type of I-T-E Circuit Breaker. It is equally adapted for single, double, triple or quadruple pole service. The "Double Arm" type renders the usual hand-switch unnecessary and is more fully described on pages 96 A, B, C, D.

The greater the amount of current, the more rapid is the movement of the plunger, and the greater the force operating upon the trigger, so that it strikes a hammer-blow, overcoming friction and being further supplemented by the spring. The greater the overload, the greater the necessity for opening the circuit; the greater the necessity for opening the circuit, the quicker it is accomplished. This, in a nutshell, is the "I-T-E" principle, and it is a principle without which circuit breakers are faulty in construction and unsatisfactory in operation.

while the generator panels shown in the cut No. 47 are provided with rotary switches serving the same purpose.

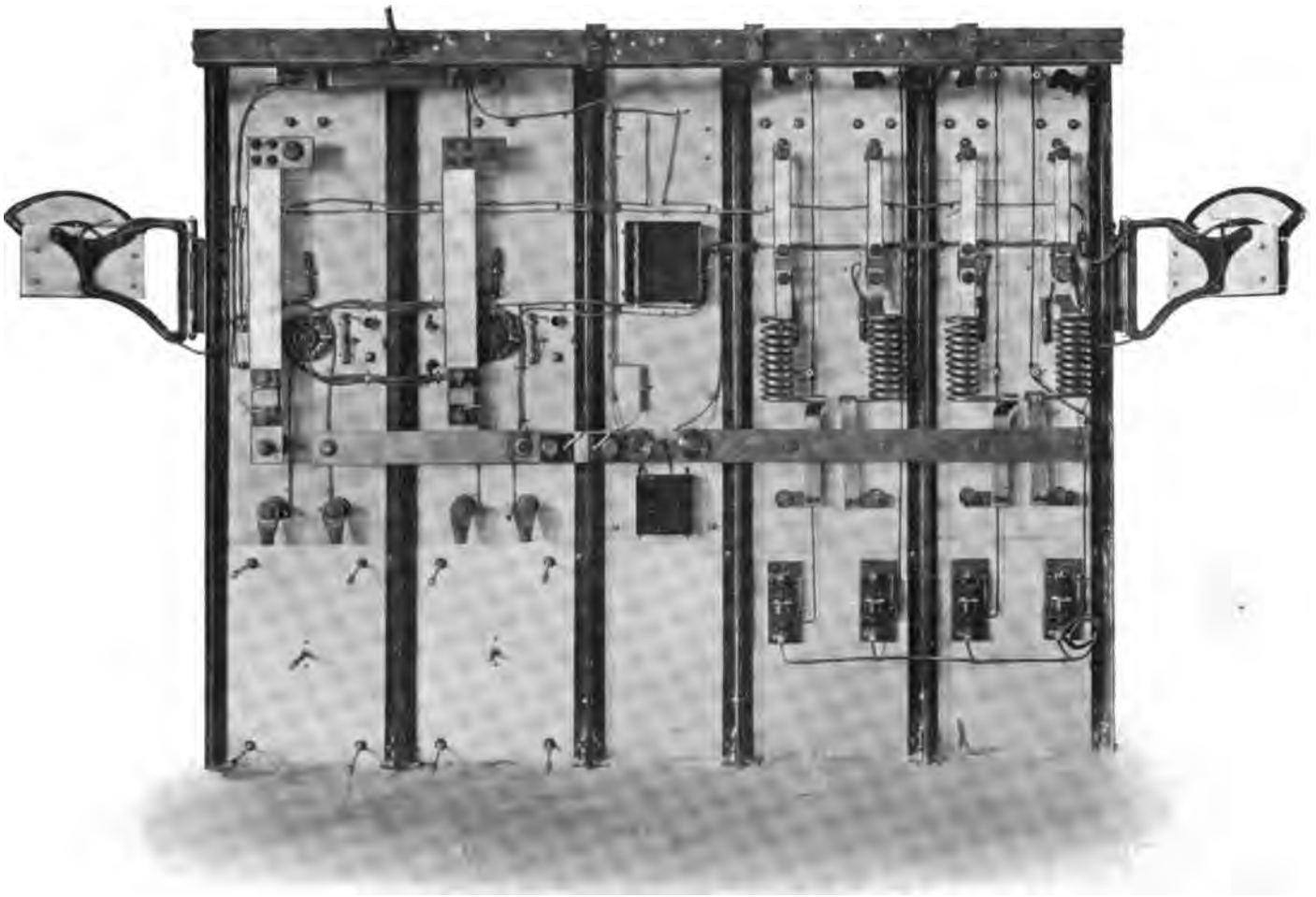


Illustration No. 48

Rear View of Street Railway Switchboards. Built of Standard Units.

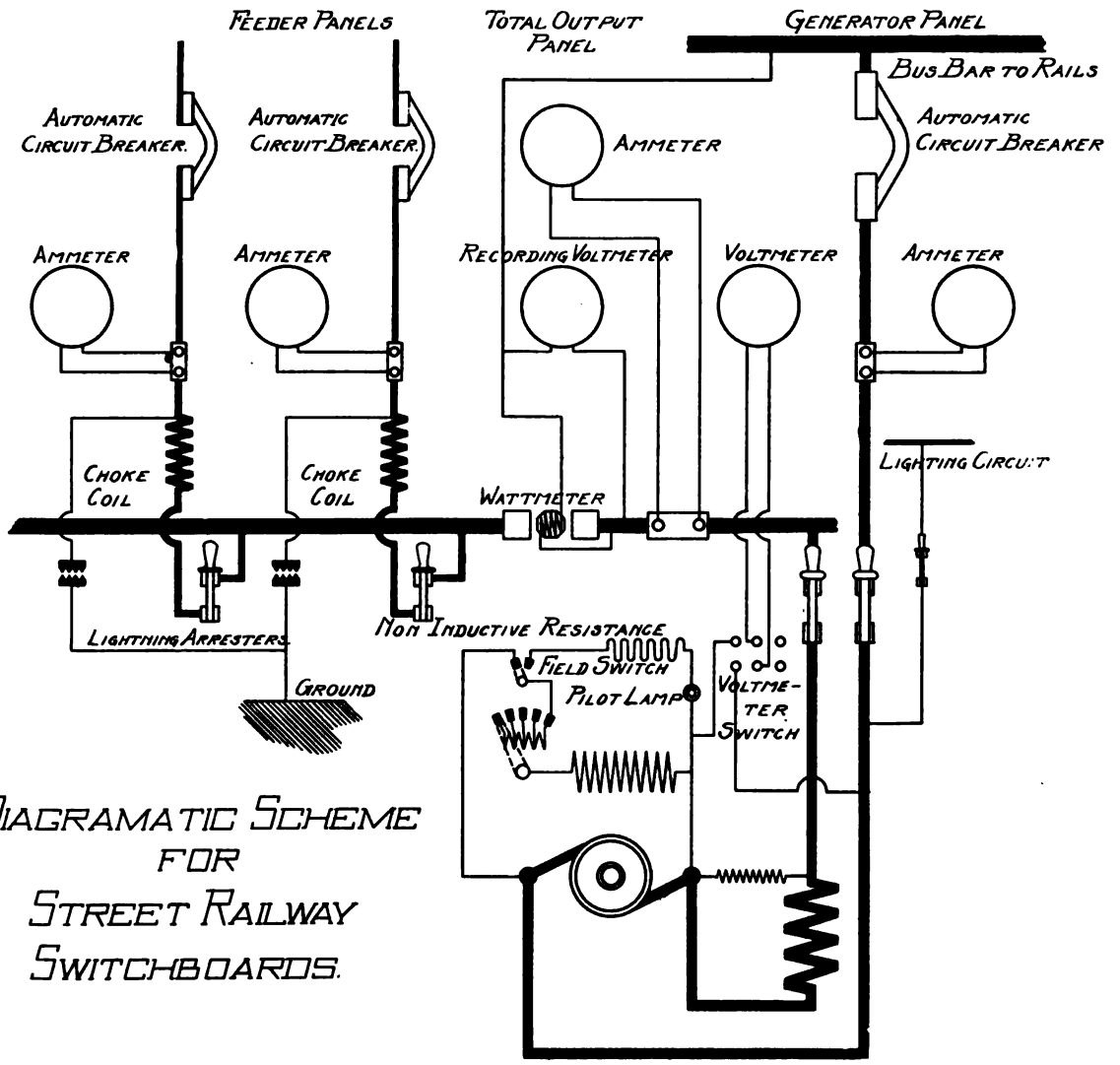
The two quick-break knife switches shown in the center of the board are located one on each side of the line, while the small switch at the right of these controls the power-house lights.

The lower section of the panel is reserved for the shunt field rheostats.

Cut No. 45 illustrates the standard feeder panel, which, in addition to the apparatus shown upon its face, is provided in the rear with the choke coil and lightning arrester.

The total output panel, cut No. 46, is for convenience and simplicity of construction usually placed between the generator and feeder panels; this is the arrangement shown in cut No. 47, of which cut No. 48 is a rear view, illustrating a complete street railway switchboard built up of standard units and representing the most approved design for this class of work.

The method of connecting the various instruments which are usually mounted upon the Street Railway Switchboard is shown in cut No. 49.



DIAGRAMATIC SCHEME FOR STREET RAILWAY SWITCHBOARDS.

While perhaps not sufficiently comprehensive to meet all conditions, the following outline specifications cover the points usually dealt with in such papers and follow current practice as dictated by the requirements of street railway work.

SPECIFICATIONS FOR SWITCHBOARD FOR . . . . . .
STREET RAILWAY COMPANY.

This specification will accompany drawings Nos. . . . . , forming a part hereof. Anything shown in the drawings and not mentioned in the specifications, or vice versa, is to be regarded as if both specified and shown in drawings. No divergence of any kind is to be made from either specifications or drawings without the approval of the engineer of . . . . . Street Railway Company.

SIZE.—The board is to consist of two generator panels, one total output panel and four feeder panels, each of dimensions as shown in accompanying drawing.

MATERIAL.—The panels are to be 2 inches thick, of the best obtainable Vermont slate, free from metallic veins or flaws; each piece is to have a $\frac{3}{8}$-inch bevel all around face; all to be black enameled on faces and sides, and all exposed sides polished.

INSTRUMENTS.—The following instruments are to be mounted by the contractor, as indicated in accompanying drawings. Except where specifically provided for otherwise, the contractor is to supply all apparatus herein specified:

PANELS Nos. 1 and 2, each:

1 Round pattern "Keystone" ammeter, 0–1500 amperes.
1 Single pole 750 volt type I-T-E Laminated circuit breaker, 1000 amperes capacity, overload adjustment to 1500.
1 Two-point voltmeter switch.
1 Single pole field switch.
1 Single pole, single throw, quick break switch, 100 amperes.
2 Single pole, single throw, quick break switches, 1000 amperes each.
1 Pilot lamp.
1 One light lamp bracket with reflector.
1 One field rheostat to be furnished by The . . . . . Railway Company.

In addition to above, Panel No. 1 is to be supplied with one illuminated dial voltmeter, 0–750 volts, mounted on swinging bracket.

PANEL No. 3.

1 "Keystone" illuminated dial ammeter, 0–2000 amperes.
1 Bristol recording voltmeter, 0–750 volts.

1 Thompson recording wattmeter, 2000 amperes normal capacity.

1 One light bracket with reflector.

PANELS Nos. 4 and 5, each:

2 Single pole, 750 volt type I-T-E Laminated 600 amperes circuit breakers with adjustment to 900 amperes.

2 "Keystone" round pattern ammeters, 0–800 amperes.

2 Quick break, single pole, single throw switches, 600 amperes capacity.

2 One light brackets with reflectors.

Panel No. 5 is also to be supplied with one "Keystone" illuminated dial voltmeter, 0–750 volts, mounted on swinging bracket. Brass labels, lettered as shown in drawing No. . . . . , are to be provided for each of the feeder circuits.

FRAME.—Each panel is to be bolted to two 3 x 3 x ¼ inches vertical angle irons, provided with suitable foot-plates and adjustable tie rod 36 inches long, adjacent angle irons to be securely bolted together. All bolt-heads and nuts showing on face of board to be of acorn pattern and copper finished, under each is to be placed copper-finished metal washer, ⅛ inch thick.

CONNECTIONS.—Connections on the back of switchboard are to be of hard drawn copper and of sectional area, such that current density shall nowhere exceed 800 amperes to the square inch. As far as possible all connections are to be of straight pieces without joints. Where joints are employed they must be sweated. Current density across bolted contacts must not exceed 200 amperes per square inch. The current to be carried by any piece of copper to be figured as equal to the rated capacity of the apparatus to which it connects.

All connections are to be included except those exterior to the board, and for these latter, cable lugs are to be provided. These are to be drilled on the basis of 1000 circular mils per ampere. All voltmeter and lamp connections to be made of No. 14 B. & S. gauge insulated wire enclosed in flexible tubing, which is to be secured to the board by means of metal clips. Leads for lighting circuit to be protected by enclosed fuses mounted on back of board at connections with main circuit. All connections of small wires to main circuit to be by means of binding posts. All wires to be run in straight horizontal and vertical lines with right-angle turns.

Slack of ammeter leads to be carried in proper length sections of hard rubber or fibre tubing securely attached to board with brass clips.

FINISH.—The exposed current-carrying parts of all apparatus upon the face of the switchboard will be polished copper; framework and cases of same will be finished dead black.

Capacity of Circuit Breaker Best Adapted for Generator of Given Size.

The following table shows the sizes of Circuit Breakers best adapted for the protection of generators of any given voltage and kilo-watt output.

The figures given in every case correspond with Rated or Normal Capacities.

Kilo-Watts Output of Generator at Rated Capacity.	For 125 Volts. Normal Capacity of Circuit Breaker.	For 250 Volts. Normal Capacity of Circuit Breaker.	For 500 Volts. Normal Capacity of Circuit Breaker.
1	8 Amperes.	4 Amperes.	———
2	16 or 20 "	8 "	4 Amperes.
3	24 or 30 "	12 "	8 "
5	45 "	20 "	10 "
7½	60 "	30 "	15 "
10	80 "	45 "	20 "
15	150 "	60 "	30 "
20	150 "	80 "	45 "
25	200 "	100 "	60 "
30	300 "	150 "	60 "
50	400 "	200 "	100 "
75	600 "	300 "	150 "
100	800 "	400 "	200 "
200	1500 "	800 "	400 "
250	2000 "	1000 "	500 "
500	4000 "	2000 "	1000 "
750	6000 "	3000 "	1500 "
1000	8000 "	4000 "	2000 "

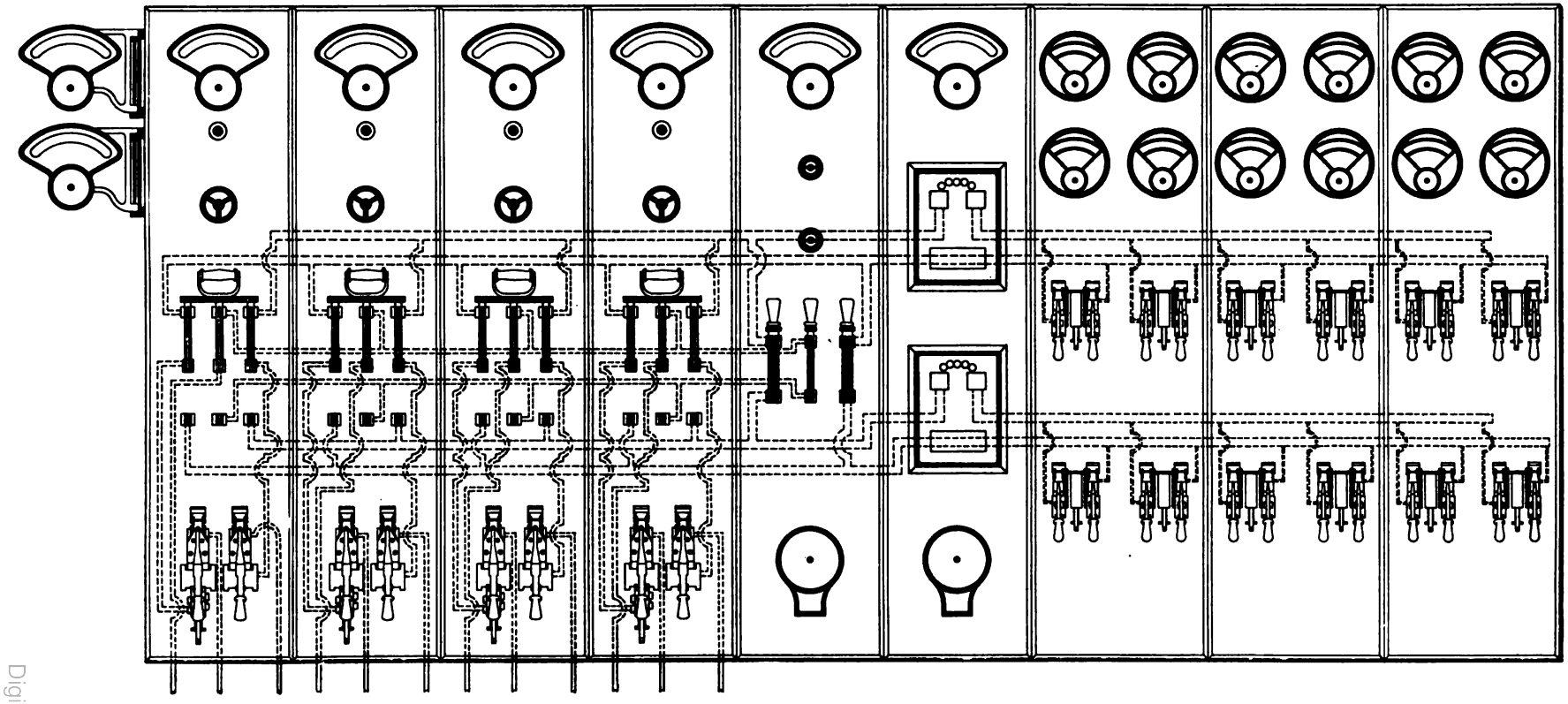
Capacity of Circuit Breaker Best Adapted for Motor of Given Size.

The following table indicates the sizes of Circuit Breakers best adapted for the protection of various sizes of motors of from ½ Horse-Power to 100 Horse-Power at Voltages of 125, 250 or 500.

The figures given in the left-hand column indicate the Horse-Power of the motor at full load, the remaining columns show the Normal Capacity of the Circuit Breakers required for each of the voltages given.

Horse-Power of Motor at Rated Load.	For 125 Volts. Normal Capacity of Circuit Breaker.	For 250 Volts. Normal Capacity of Circuit Breaker.	For 500 Volts. Normal Capacity of Circuit Breaker.
½	4 Amperes.	———	———
1	8 "	4 Amperes.	———
2	16 or 20 "	4 "	4 Amperes.
3	24 or 30 "	12 "	8 "
5	45 "	20 "	10 "
7½	60 "	30 "	20 "
10	80 "	40 "	20 "
15	150 "	60 "	30 "
20	200 "	80 "	45 "
25	200 "	100 "	60 "
30	300 "	150 "	60 "
40	300 "	150 "	80 "
50	400 "	200 "	100 "
75	600 "	300 "	150 "
100	800 "	400 "	200 "

SWITCHBOARD FOR A MANUFACTURING PLANT
SHOWING USE OF -DUBLARM- CIRCUIT BREAKERS



SWITCHBOARD FOR A MANUFACTURING PLANT.

The accompanying drawing serves to show the general arrangement of a switchboard for a large manufacturing establishment employing electricity both for lighting and power. As may be seen, the board controls four generators and supplies twelve feeders. The system is two-wire, 125 volts, direct current. The generator leads are run under the floor to the switchboard; it is found convenient, therefore, to place the machine circuit breakers at the bottom of the board. As these instruments are of the "Laminated" type and closed by an easy downward movement of the handle, this arrangement is entirely satisfactory.

The circuit breakers are of the "Dublarm" type, thus securing absolute protection even should they be manipulated while the switches in series with them are closed. Each generator is connected to the blades of a three-pole, double-throw switch. Two sets of bus bars are provided, each running the entire length of the board, the connections being such that any generator may be run upon either set of buses. This arrangement permits of the lighting circuits being supplied, when so desired, independently of the generators feeding the power circuits. As the power load may be subject to heavy variations, with resulting fluctuations in voltage, the advantage of this plan is apparent.

Each generator panel is supplied with its ammeter, showing instantly whether each unit is taking its due share of the load, while pilot lights, located below ammeters, serve as a ready indication of any undue variation of voltage. Two illuminated dial voltmeters are supplied, each mounted on an adjustable bracket. It is the intention that one voltmeter shall remain in

connection with each pair of buses, but by means of the two rotary voltmeter switches, located on the total output panel, each one may be connected to either set of bars or used as a ground detector.

The three switches on the total output panel are for the purpose of tying together the two sets of buses, should an emergency render it desirable to supply simultaneously both light and power circuits from the same generators.

Two Thompson wattmeters serve to record the power delivered to the power and lighting buses respectively, and each set of bars is also provided with its ammeter and recording voltmeter.

Upon the feeder panels the usual switches are dispensed with, an arrangement made possible by the use of "Dublarm" Circuit Breakers, by means of which each feeder is connected to its proper bus bars. In the board under consideration, the lighting bus bars are located just above the power buses and near the center of the board. Just above them are mounted the circuit breakers for the lighting circuits, the feeders for these circuits being carried off from the top of the board.

The Circuit Breakers controlling the power circuits are placed toward the bottom of the board, these feeders leaving at the bottom of the board and being run under the floor to their respective ducts. For convenience in making readings, all of the feeder circuit ammeters are placed toward the top of the board, those for the lights being above those for the power circuits.

The arrangement above outlined is one of great simplicity and is also desirable on account of the flexibility which it gives. Not only may light and power circuits be kept entirely independent, but any or all generators may be connected with either or both sets of buses. As will be seen also, the plan is one which permits of a large number of circuits being effectively controlled from a

switchboard of very moderate dimensions and characterized by great simplicity of construction.

SPECIFICATIONS FOR SWITCHBOARD FOR . . . . . .
MANUFACTURING COMPANY.

These specifications will accompany drawings Nos. . . . . forming a part hereof. Anything shown in the drawings and not mentioned in the specifications, or vice versa, is to be regarded as if both specified and shown in drawings. No divergence of any kind is to be made from either specifications or drawings without the approval of the engineer of the . . . . . Manufacturing Company.

PLAN.—The system is to be two-wire, direct current, 125 volts. Current is to be supplied by four generators of the following capacities . . . . . Two sets of bus-bars are to be provided, one to feed the power circuits and one to feed the lighting circuits. Each set of bus-bars is to be proportioned for carrying the total current of all generators running at full load, and connections of generator switches are to be so arranged that each generator may be operated on either pair of bus-bars.

SIZE.—The board is to consist of four generator panels, two total output panels, and three feeder panels, each of dimensions as shown in accompanying drawing.

MATERIAL.—The panels are to be not less than one and one-half inches thick (1½ inches), of black enameled slate, free from metallic veins or flaws, all front edges to have one-quarter inch (¼ inch) bevel faces, and all exposed sides polished.

APPARATUS.—The following apparatus is to be mounted by the contractor, as indicated in accompanying drawings. Except where specifically provided for otherwise, the contractor is to supply all apparatus herein specified.

FOUR GENERATOR PANELS, EACH.

1 "Keystone" illuminated dial, 0 to . . . . . (size) amperes ammeter.
1 Double pole, automatic, "Dublarm" circuit breaker, ... amperes capacity. (Capacity of generator.)
1 Pilot lamp.
1 Enamel field rheostat of approved type.

1 Triple pole, double throw knife switch of . . . . . amperes capacity. (Capacity of generator.)

In addition to above there will be two "Keystone" illuminated dial voltmeters, 0–125 volts, mounted on swinging brackets at end of board.

TOTAL OUTPUT PANELS:

2 "Keystone" illuminated dial ammeters.

2 Voltmeter switches, so connected that the following readings may be taken with either voltmeter:

Voltage across any generator leads.
" " lighting buses.
" " power buses.
" from positive power bus to ground.
" " negative " " " "
" " positive lighting bus to "
" " negative " " " "

3 Single pole, single throw knife switches, of . . . . amperes capacity, each, for tying power and lighting buses.

2 Thompson recording wattmeters, one of . . . . . amperes and one of . . . . . amperes, at 125 volts, in circuits of power and lighting buses respectively.

2 Bristol recording voltmeters.

THREE FEEDER PANELS EACH.

4 "Dublarm" I-T-E circuit breakers.

4 "Keystone" round pattern ammeters.

Each of the above to be of capacities as shown in accompanying drawing.

4 Brass labels, each engraved with name of circuit controlled.

INSTRUMENTS.—All instruments to be of the permanent magnet type, and to be capable of being left continuously in circuit. They shall be left by the contractor correctly calibrated. No splices of any description to be allowed in shunt cords to voltmeters and ammeters.

FRAMES.—Each panel to be bolted to two 3 x 3 x ¼ inches vertical angle irons, provided with suitable foot-plates and adjustable tie rod. Adjacent angle irons to be securely bolted together.

The bottom of the board will rest on a black slate sill three inches (3 inches) high by two inches (2 inches) thick, sills to be width of panels and have ¼-inch bevel edge.

CONNECTIONS.—Connections on the back of switchboard are to be of hard drawn copper, and of sectional area such that current density shall nowhere exceed 800 amperes to the square inch. The bus bars, and as far as possible all connections, are to be of straight pieces without joints.

Where joints are necesssary they must be sweated. Current density across bolted contacts must not exceed 200 amperes per square inch. The current to be carried by any piece of copper to be figured as equal to the rated capacity of the apparatus to which it is connected.

The board must be finished with all connections complete and ready for connecting to various circuits, and for which the contractor will supply cable lugs drilled on the basis of 1000 circular mils per ampere.

All voltmeter and lamp connections are to be made of No. 14 B. & S. gauge fire- and weather-proof wire, secured to the board by means of brass clips. Leads for lighting circuits to be protected at connections with main circuit by enclosed fuses, mounted on individual bases on back of board. All connections of small wires to main circuit to be made by means of binding posts. All wires to be run in straight, horizontal and vertical lines with right-angle turns.

Slack of ammeter leads to be carried in proper length sections of hard rubber or fiber tubing, securely attached to board with brass clips.

All wiring and construction shall be in accordance with rules of Fire Underwriters.

FINISH.—The exposed current-carrying parts of all apparatus upon the face of the switchboard will be polished copper, frame-work and cases of same will be finished dead-black. Instruments to have polished copper and black faces. All bolt-heads and washers upon face of board to have polished copper finish.

NOTE.—In drawing up specifications it is good practice for the engineer to specify the makes of apparatus which will meet with his approval, as otherwise inferior makes may be substituted. In some cases there are no drawings furnished with the specifications, and in such instances the engineer should see that the contractor submits blue-prints, showing exactly what he proposes to furnish.

A SWITCHBOARD WITHOUT SWITCHES.

A very compact switchboard in which switches are entirely displaced by circuit breakers is outlined in the accompanying cut. The board consists of Generator, Total output and Distributing panels placed in their usual relative positions.

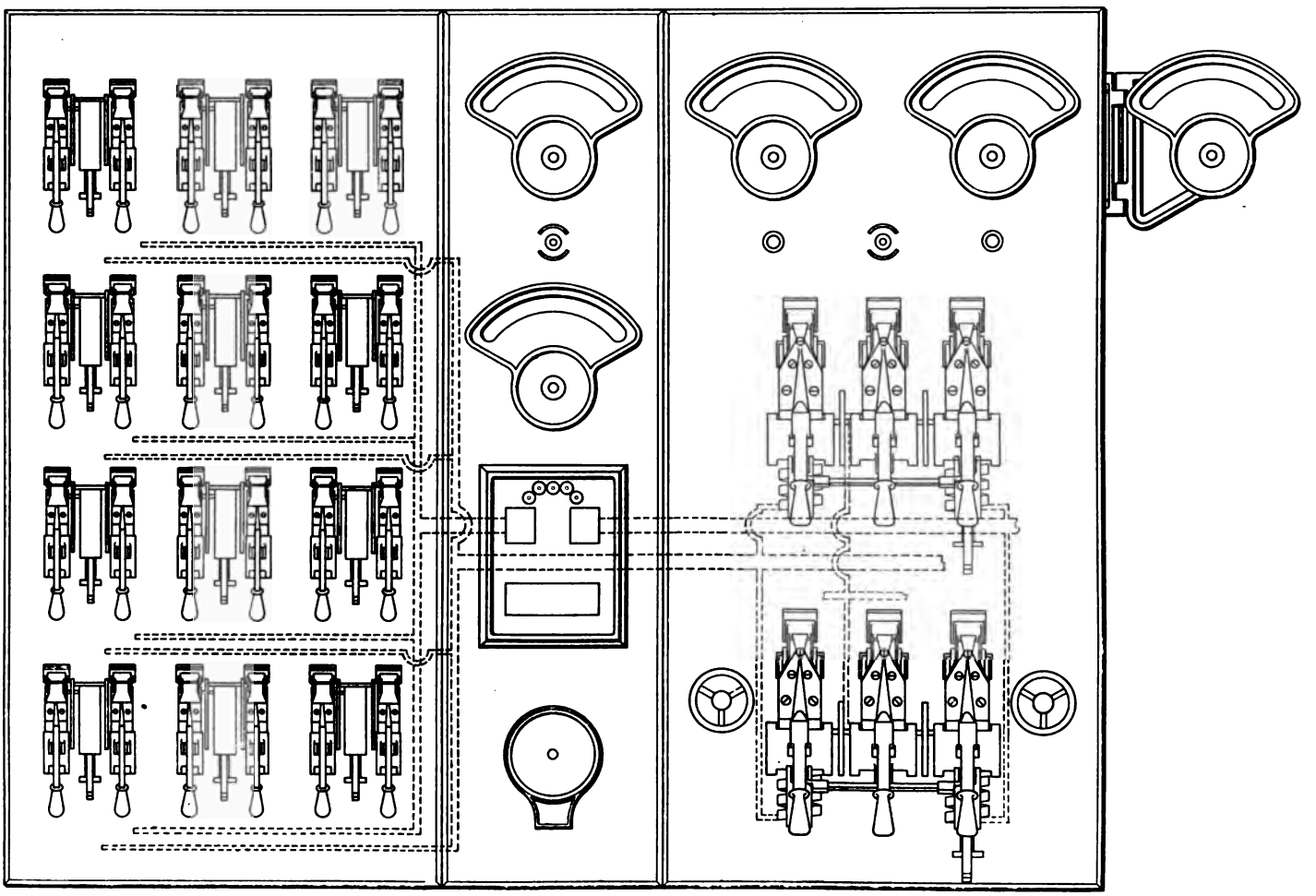
Provision is made for two generators, which are connected with the bus bars by means of triple-pole independent-arm circuit breakers. These have the usual overload operation, and in addition will open the circuit should the current flow through them in the reverse direction, a possibility which in the parallel operation of generators is by no means remote; resulting, as it may, either from careless handling of the apparatus, imperfect regulation of the speed of the prime movers, or accident to one of the field circuits. Each generator is provided with an ammeter and pilot lamp. To the right of the board, mounted on a swinging bracket, which may be adjusted so that the scale of the instrument can be seen conveniently at any desired point, is an illuminated dial voltmeter; the voltmeter switch on the generator panel permits of this instrument being used to measure the voltage of either generator, or to detect grounds on either side of the line.

The total output panel is provided with a voltmeter which ordinarily indicates the voltage at the bus bars. This instrument is also controlled by a switch connecting with the same points as the generator voltmeter switch; thus the two instruments may be employed to check each other, and injury to one of them would occasion no serious inconvenience.

An ammeter measuring the total current passing through the bus bars, a wattmeter recording the total power, and a Bristol recording voltmeter make the total output panel complete.

The feeders are connected to the bus bars by means of double pole, double arm ("Dublarm") circuit breakers, thus insuring for the circuits perfect protection from overloads. This arrangement of feeders is one which combines economical construction with effective operation. It is constantly growing in favor with leading engineers.

LAYOUT OF SWITCHBOARD
IN WHICH SWITCHES ARE DISPLACED
BY -DUBLARM- CIRCUIT BREAKERS



ELECTRICAL CONSTANTS OF COPPER AND ALUMINUM BARS

The tables given herewith furnish the electrical constants of aluminum and of copper bars which are most likely to be of use to the switchboard designer. The current which any given section may carry is calculated upon the basis of a load factor of 50 per cent. and the densities given are those which for average conditions of radiation would result in a temperature rise of about 10 degrees Centigrade. Where the load factor is to be 100 per cent. and it is desired to keep the heating within the above limits, the current densities must be halved.

The data given shows in an interesting manner the relative values of copper and aluminum in switchboard construction.

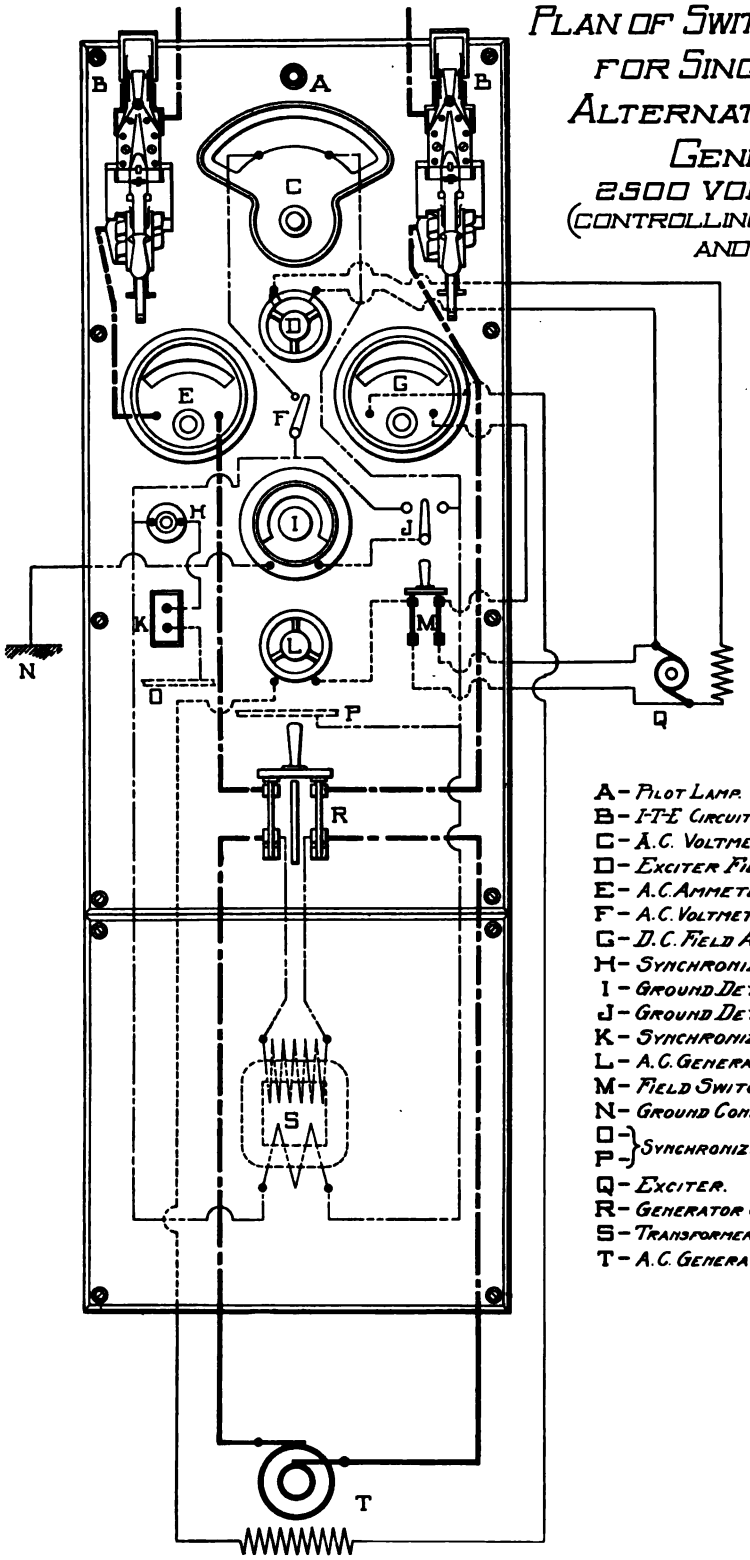
COPPER BAR DATA

Size	Amps.	Amps. Per Square Inch	Circular Mils	Square Mils	Ohms Per Foot	Weight Per Foot
1 x ¼ in.	433	1732	318310	250000	.0000336	.97
1¼ x ¼ in.	530	1696	397290	312000	.0000269	1.21
1½ x ¼ in.	626	1669	477465	375000	.0000223	1.45
1¾ x ¼ in.	725	1657	556400	437000	.0000192	1.70
1¼ x ⅜ in.	676	1442	596830	468750	.0000179	1.82
1½ x ⅜ in.	798	1418	716200	562500	.0000149	2.18
1¾ x ⅜ in.	916	1395	835600	656250	.0000128	2.54
2 x ⅜ in.	1035	1380	954930	750000	.0000112	2.92
2¼ x ⅜ in.	1154	1367	1074300	843750	.00000995	3.27
2½ x ½ in.	1500	1200	1591550	1250000	.00000672	4.86
2½ x ⅝ in.	1715	1097	1989440	1562500	00000537	6.07
2 x ½ in.	1222	1222	1273240	1000000	00000840	3.89
No. 0000 B. & S.	267	1606	211600	166190	.0000505	.64
½ in. Round	305	1552	250000	176350	.0000428	.76
⅝ in. "	426	1388	390625	305796	.0000273	1.18
¾ in. "	560	1267	562500	441787	.0000190	1.71
1 in. "	861	1096	1000000	785400	.0000107	3.05

ALUMINUM BAR DATA

Size	Amps.	Amps. Per Square Inch	Circular Mils	Square Mils	Ohms Per Foot	Weight Per Foot
1 x ¼ in.	347	1388	318310	250000	.0000534	.291
1¼ x ¼ in.	424	1360	397290	312000	.0000428	.362
1½ x ¼ in.	500	1334	477465	375000	.0000356	.435
1¾ x ¼ in.	580	1327	556400	437000	.0000305	.507
1¼ x ⅜ in.	530	1131	596830	468750	.0000285	.544
1½ x ⅜ in.	638	1130	716200	562500	.0000237	.653
1¾ x ⅜ in.	733	1117	835600	656250	.0000203	.762
2 x ⅜ in.	830	1107	954930	750000	.0000178	.871
2¼ x ⅜ in.	925	1096	1074300	843750	.0000158	.980
2½ x ½ in.	1200	960	1591550	1250000	.0000107	1.45
2½ x ⅝ in.	1400	897	1989440	1562500	.00000855	1.81
2 x ½ in.	980	980	1273240	1000000	.0000134	1.16
No. 0000 B. & S.	211	1266	211600	166190	.0000803	.193
½ in. Round	244	1260	250000	176350	.0000680	.228
⅝ in. "	340	1108	390625	305796	.0000436	.355
¾ in. "	448	1013	562500	441787	.0000302	.513
1 in. "	690	880	1000000	785400	.000017	.911

Plan of Switchboard Panel for Single Phase Alternating Current Generator 2300 Volts or Less (Controlling-A-C-Generator and Exciter)



A - Pilot Lamp.
B - I-T-E Circuit Breakers.
C - A.C. Voltmeter.
D - Exciter Field Rheostat.
E - A.C. Ammeter.
F - A.C. Voltmeter Switch.
G - D.C. Field Ammeter.
H - Synchronizing Lamp.
I - Ground Detector.
J - Ground Detector Switch.
K - Synchronizing Plug.
L - A.C. Generator Rheostat.
M - Field Switch.
N - Ground Connection.
O, P } Synchronizing Busses.
Q - Exciter.
R - Generator Switch.
S - Transformer.
T - A.C. Generator.

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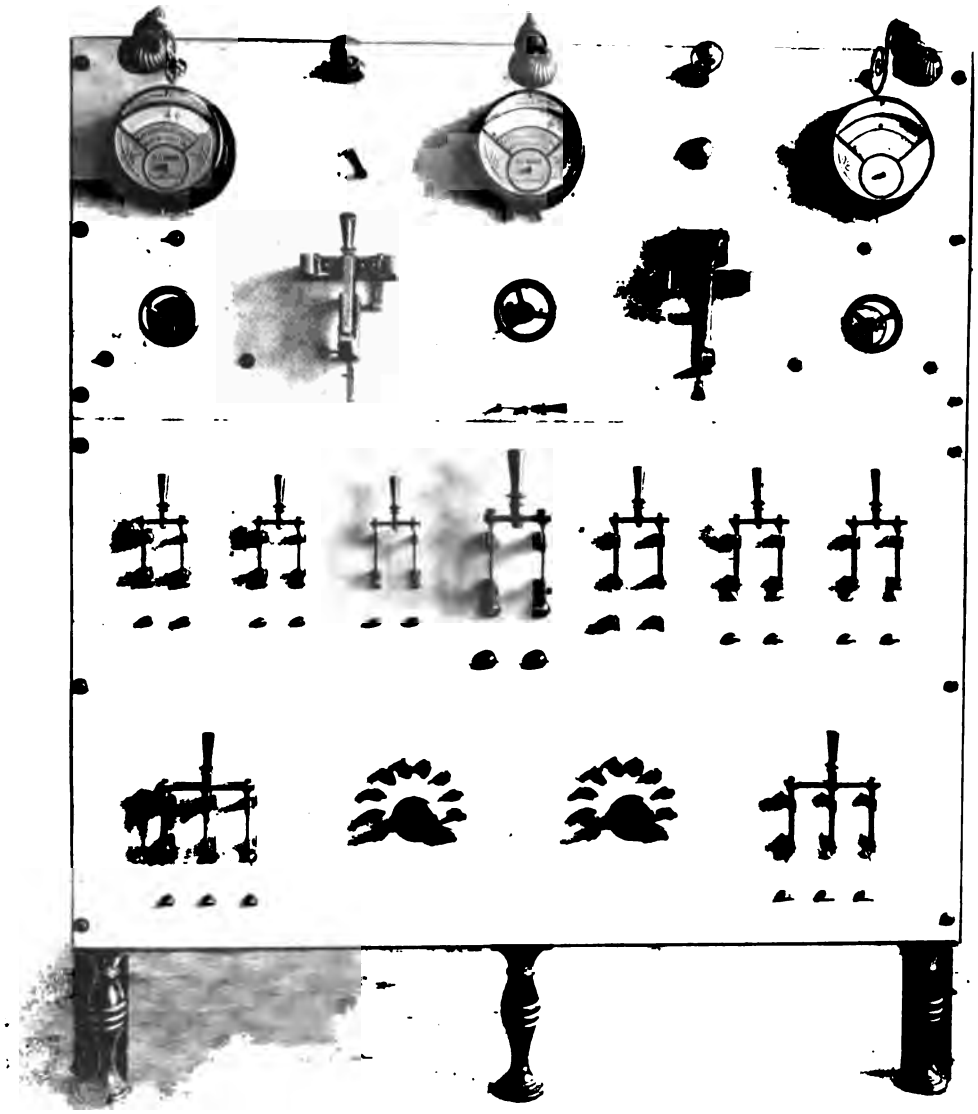

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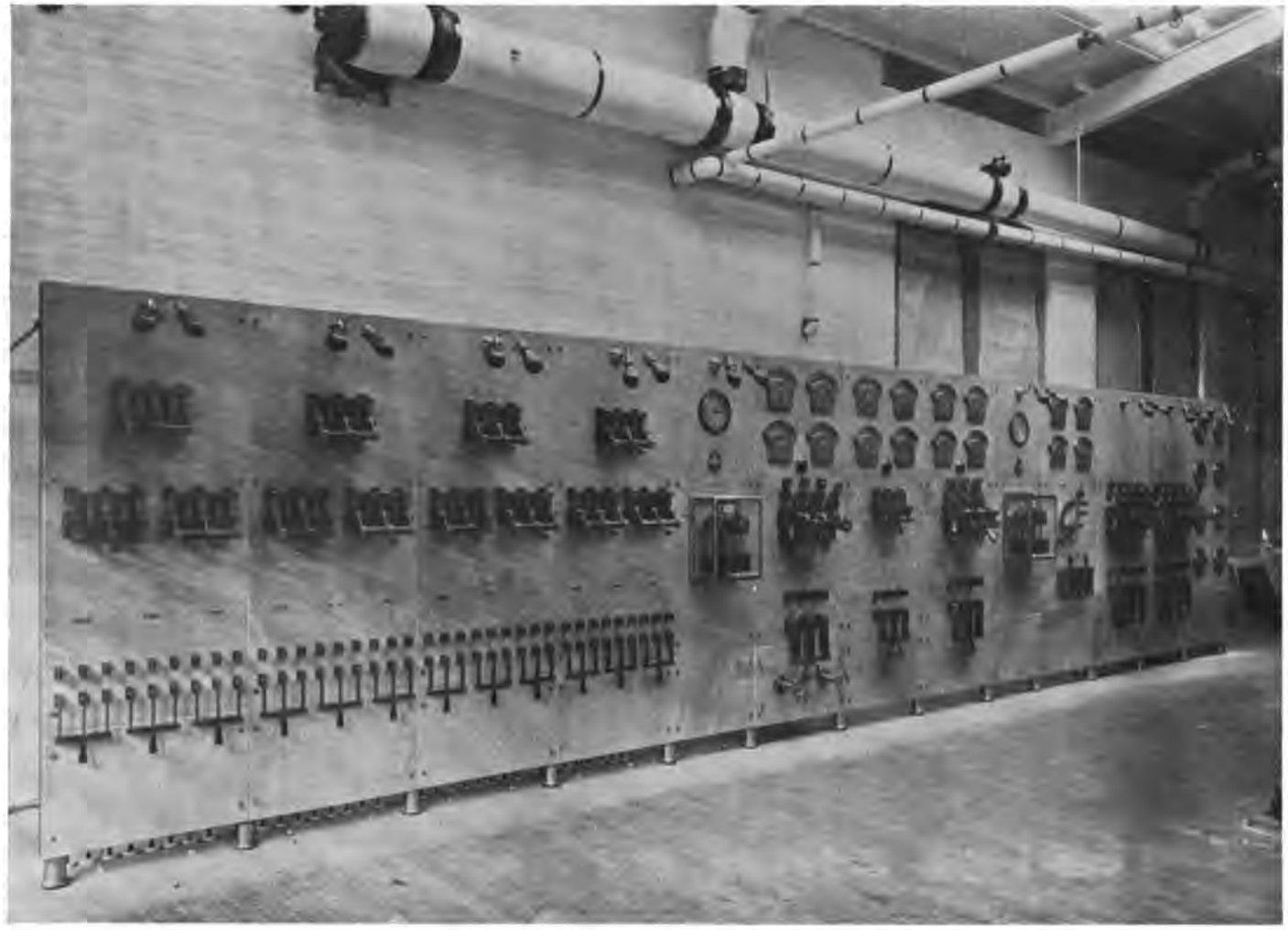

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KERN DODGE, Engineer
Built by The Walker Electric Company, Reg., Philadelphia

A VIRGINIA RAILWAY BOARD

BUILT FOR THE VANDERGRIFT CONSTRUCTION COMPANY

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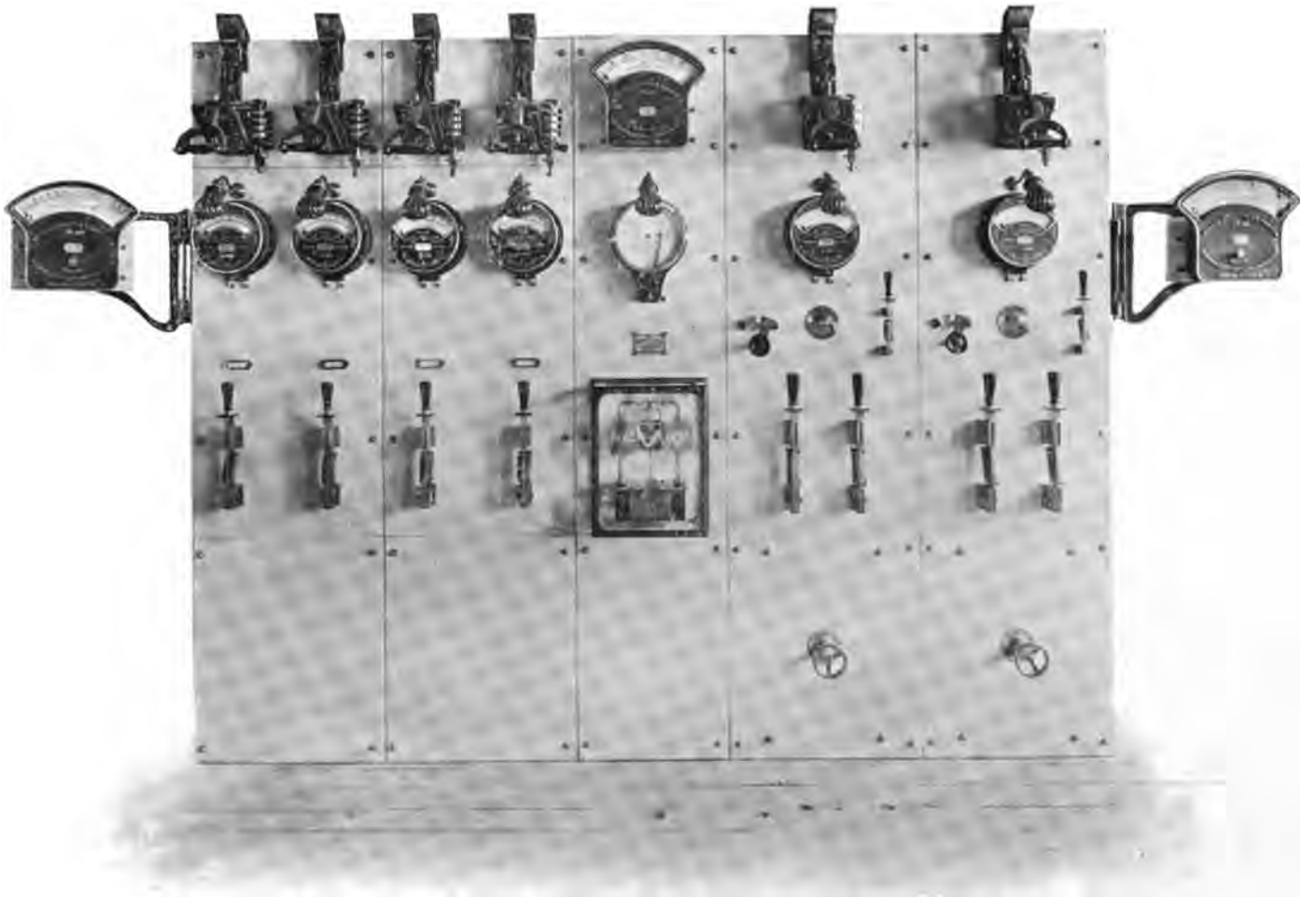

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The Largest Independent Switchboard Builders in the Country

A little pamphlet on Railway Boards upon request

FRONT VIEW—Diameter, 4 inches

BACK VIEW—Diameter, 6 inches

FUNCTION OF A VOLTMETER SWITCH

ECONOMY was the mother of the voltmeter switch. It is rather an expensive matter to have a voltmeter for every circuit, and because different people practice economy differently there are a great many kinds of voltmeter switches on the market, and most of them are so flimsy that they are worthless. It isn't the principle that gives trouble, it is the *switch*. We have developed a voltmeter switch up to the point where it overcomes the following objections in other types, which objections were present in our own earlier models:

The liability to injury from careless handling.
The liability to swell when exposed to dampness.
The liability to contract in the dry engine-room atmosphere.
The liability to loosen and turn round after once being set.
The liability to warp and throw the contacts out of line.
Electrical weaknesses.
The liability to collect dust in contact pockets destroy electrical connection in whole or
The liability to spread a film of met
button and cause short-circuit.

In the Walker Improved Type none of these objections can be found and it will wear for

If a voltmeter switch is used, you need have no anxiety about the calibration of the v machines are thrown together, for the same voltmeter will be used for *both* and *all* machines.

If a voltmeter switch is used with every voltmeter, if one voltmeter should give out, the other can be made to do the work of both while it is being repaired or recalibrated, and then the others can be checked up with the new one. The switches can also be arranged to give ground readings in volts, and if the instrument is calibrated in *ohms* as well as volts (which is common practice now and costs only a trifle) the ground can be read from the voltmeter scale in ohvolts.

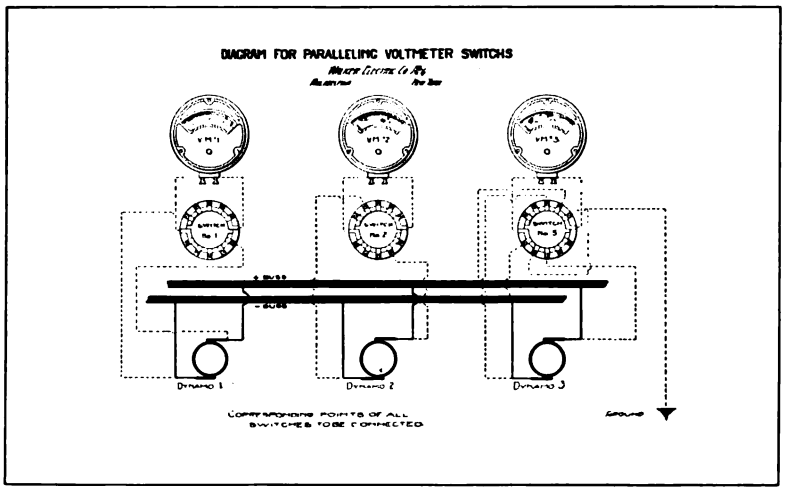

Diagram here gives for several mac
voltme
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appreciated.

The Walker Improved is beautifully finished and costs less than one-third the price of a round pattern instrument.

One 7/8-inch hole in the board is sufficient to mount the switch.

Send for one and if you don't like it we will be glad to take it back.

It is suggested that if you want the "best switch in the world," you specify the Walker Improved Type.

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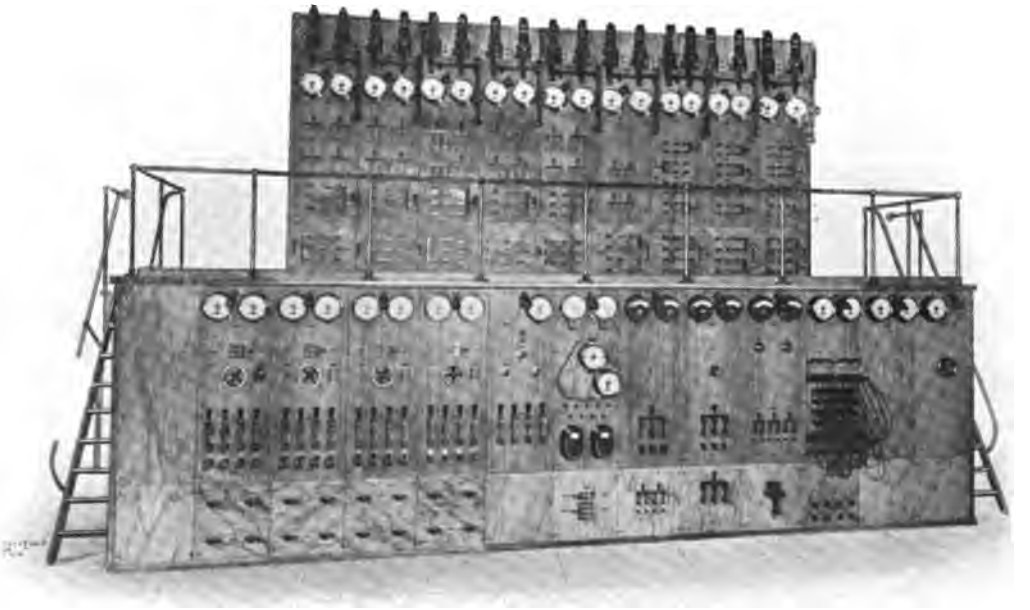
Erected by us June, 1902. Dimensions: 17 ft. 6 in. high, 35 ft. long.

Watch for the cut of the Pennsylvania Railroad's Camden board, which we will erect next Fall



Electric Company, Reg.

The Largest Independent Switchboard Builders in the Country

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A LITTLE PAMPHLET, "A FEW SWITCHBOARDS," ON REQUEST

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OF
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If you have any circuit breaker problems not to be solved by the use of our standard types, let us know your requirements; doubtless we have a SPECIAL which will entirely serve your purpose.

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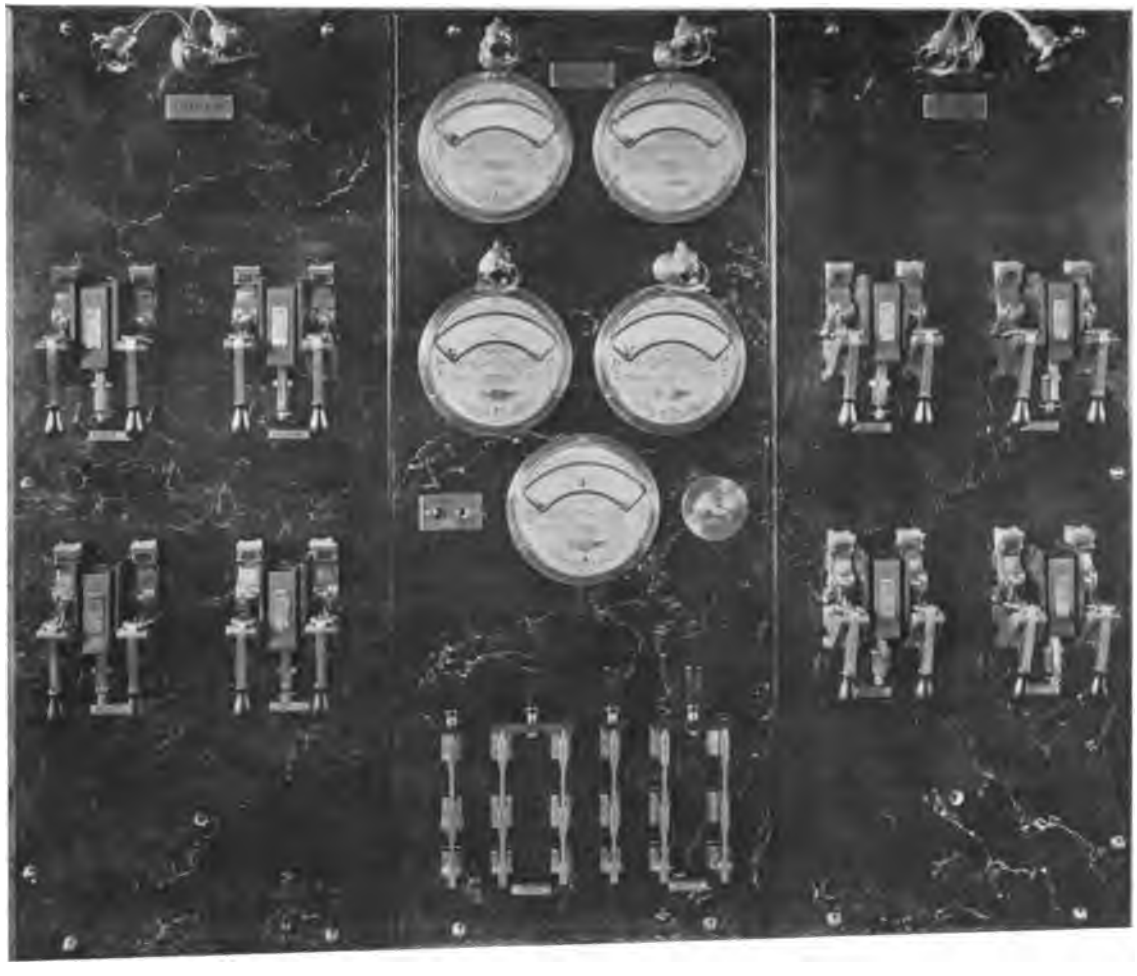
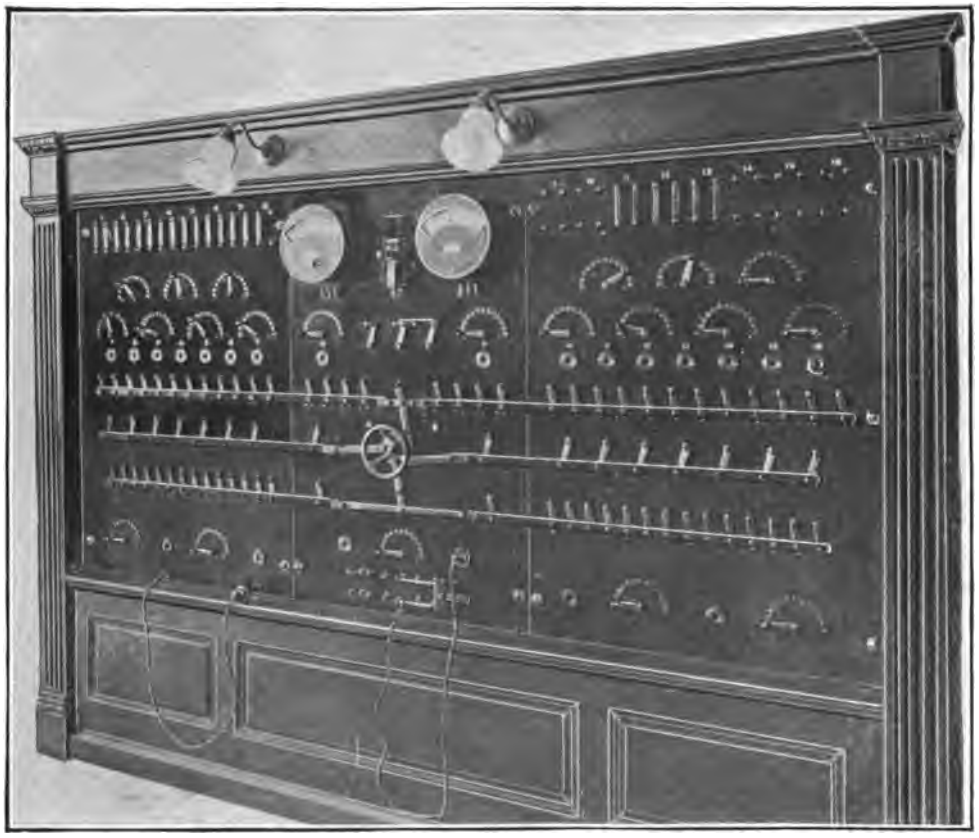


Switchboard Installed at

SANDY HOOK PROVING GROUNDS, New Jersey



Switchboard for the Complete Control of a Sixteen-Circuit Fire Alarm System

CROUSE-HINDS ELECTRIC COMPANY

Main Office and Works
SYRACUSE, NEW YORK, U. S. A.

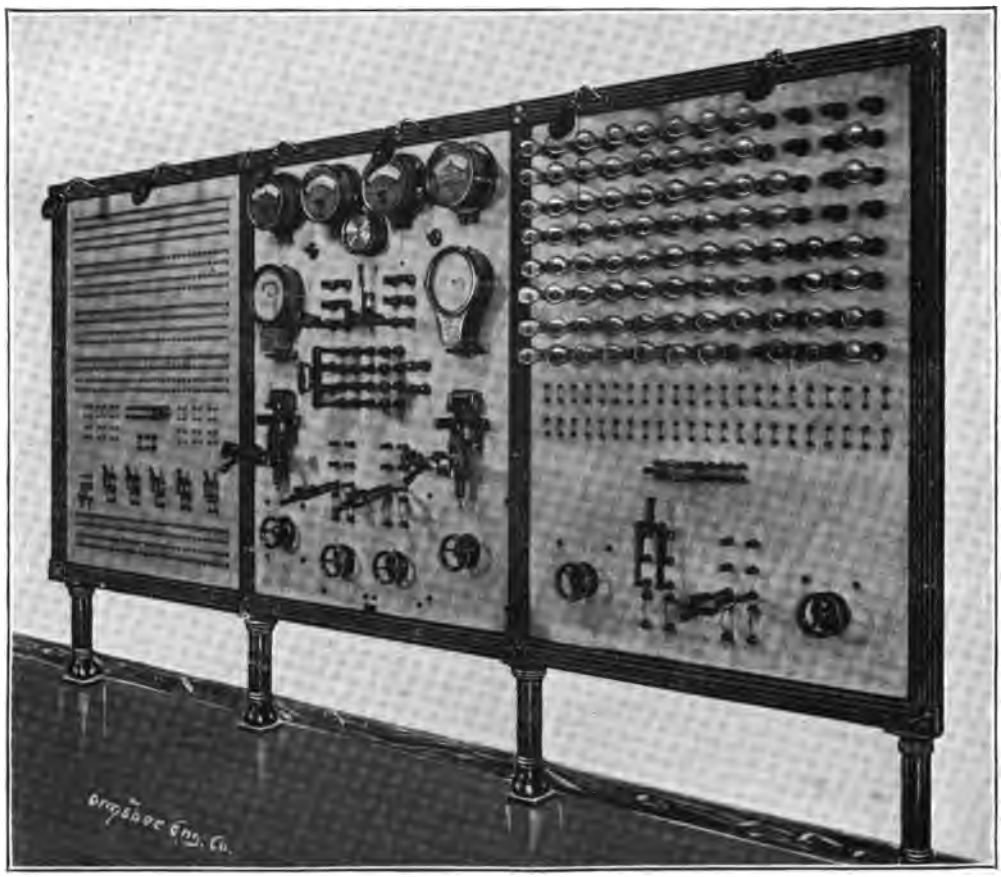
SALES OFFICES

NEW YORK: 23 Dey Street
CHICAGO: 130 W. Jackson Boulevard
BOSTON: New England Building
SAN FRANCISCO: Mills Building
CINCINNATI: 234 West Fourth Street

AT EACH OF OUR OFFICES WE CARRY A FULL LINE OF

KNIFE SWITCHES AND PANEL BOARDS

FOR IMMEDIATE DELIVERY



Switchboard for the Complete Control of a Centralized Energy Telephone System

CROUSE-HINDS ELECTRIC COMPANY

ELECTRICAL AND MECHANICAL ENGINEERS

MANUFACTURERS OF

SWITCHBOARDS

FOR THE CONTROL OF

Railway, Power, Lighting, Fire Alarm and Police Telegraph

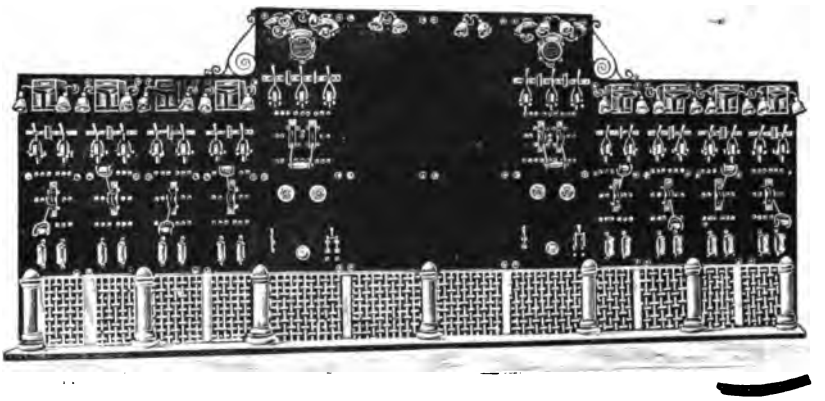
SYSTEMS

AND SPECIAL SWITCHBOARDS TO MEET ANY REQUIREMENTS

SWITCHBOARDS

DIRECT
ALTERNATING

NONE TOO LARGE
NONE TOO SMALL
To receive our best attention



Give us a chance to figure on
your Switchboard Specifications

W. S. HILL ELECTRIC CO.

NEW BEDFORD, MASS.

WE BUILD HIGH-GRADE—RELIABLE—STANDARD

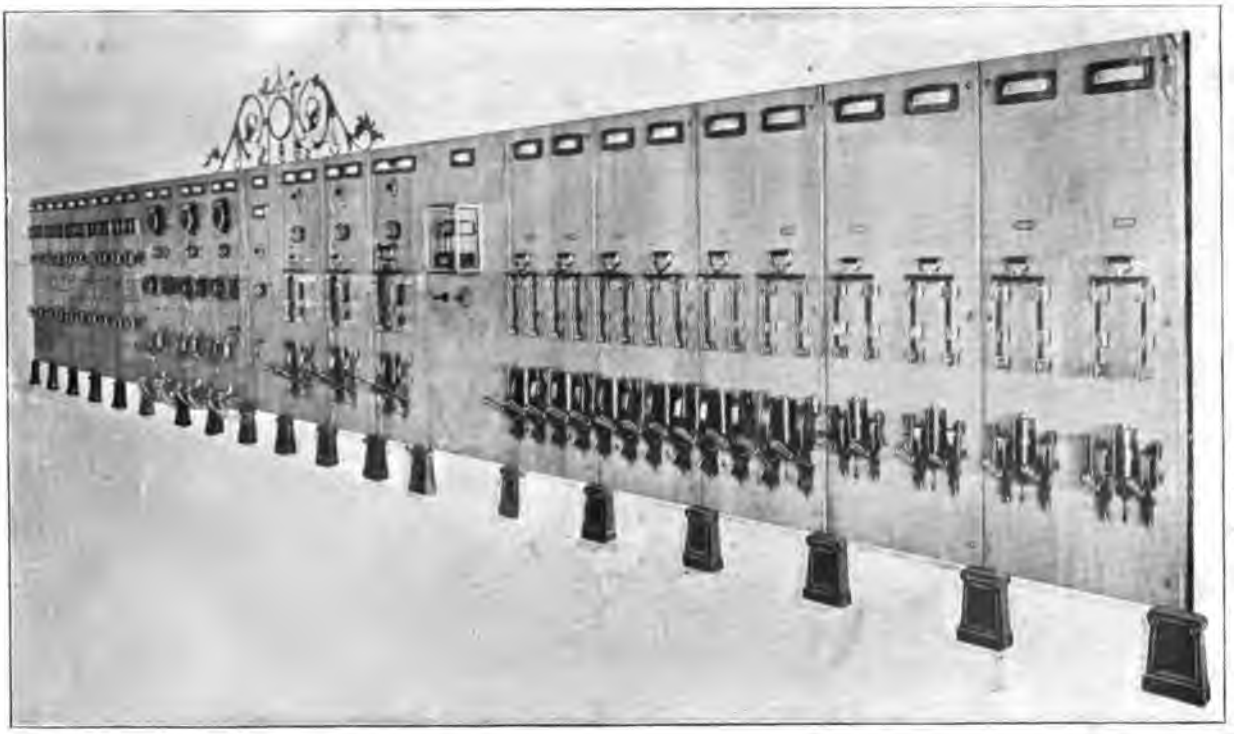
SWITCHBOARDS

WE GUARANTEE QUALITY THEY NEVER DISAPPOINT

WE GIVE SATISFACTION

WRITE FOR ESTIMATES WE PROMISE PROMPT SERVICE

ANDRAE SWITCHBOARDS ARE RECOGNIZED EVERYWHERE FOR THEIR SERVICE, EFFICIENCY AND WORKMANSHIP



SWITCHBOARD BUILT BY JULIUS ANDRAE & SONS CO. FOR ARMOUR & CO., CHICAGO, ILL.

The above half-tone illustrates the switchboard we installed in the Armour Co. plant, at Chicago. It is a valuable testimonial to our high-grade work.

WE SELL EVERYTHING ELECTRICAL

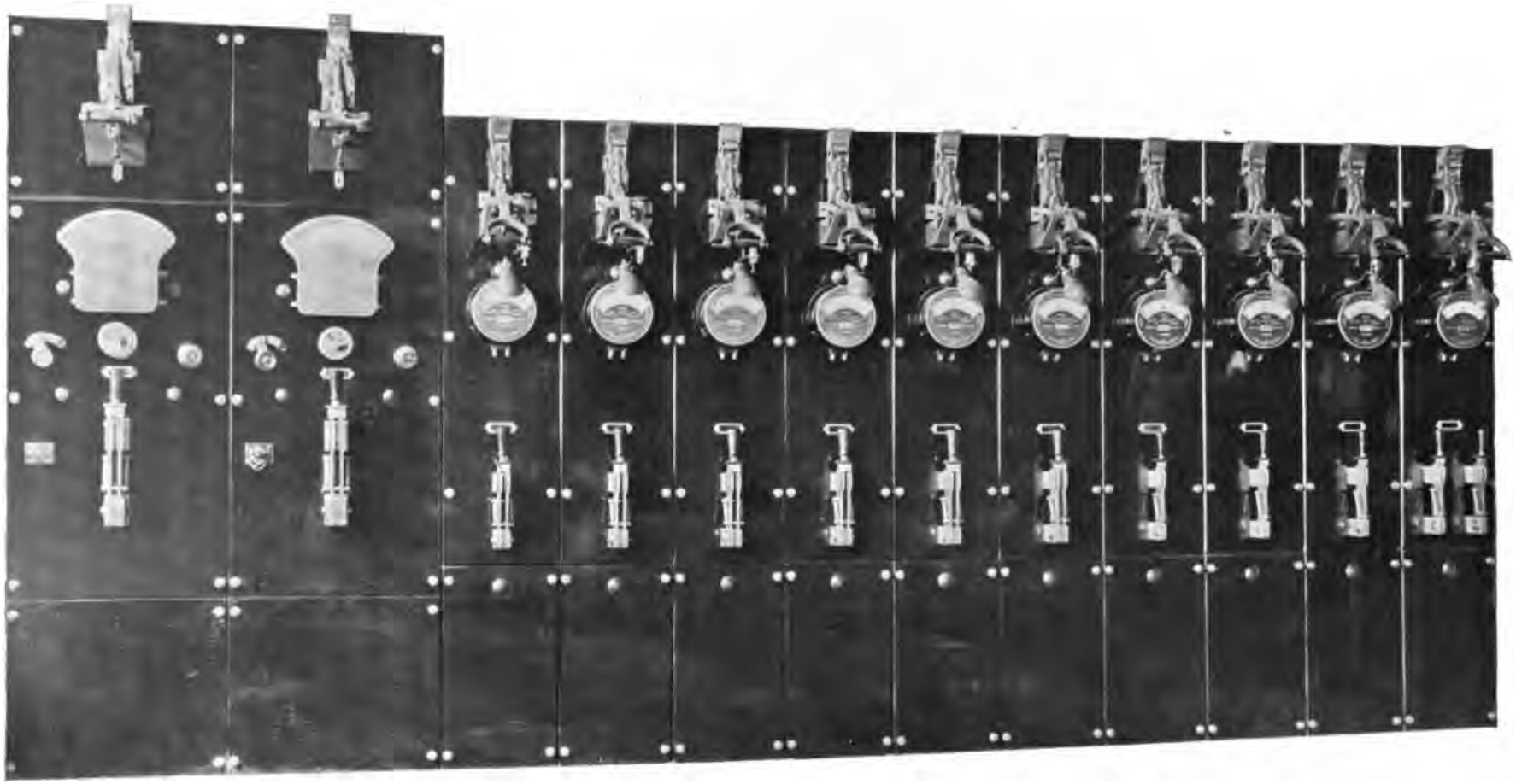
Dynamos, Motors, Supplies, etc., for Factories, etc. Complete Electric Lighting Plants and Telephone Systems. Electric Supplies of Every Description.

WRITE FOR PRICES

JULIUS ANDRAE & SONS CO.

225 West Water St., MILWAUKEE, WIS.

Our 100-page Illustrated Catalogue of Telephones and Supplies will be sent Free for the asking



METROPOLITAN STREET RAILWAY CO.

Kansas City, Mo.

Built by The Walker Electric Company, Reg., Philadelphia

Installed by B-R Electric Co., Kansas City, Mo.

Lighting, Railway and Power

APPARATUS AND SUPPLIES

AGENTS

THE CUTTER COMPANY
I-T-E Circuit Breakers
Keystone Instruments

THE HAZARD MFG. COMPANY
Wires and Cables

NORTHERN ELEC. MFG. CO.
Dynamos and Motors

THE OHIO BRASS COMPANY
Overhead Line Material

THE R. D. NUTTALL COMPANY
Trolleys, Gears and Pinions

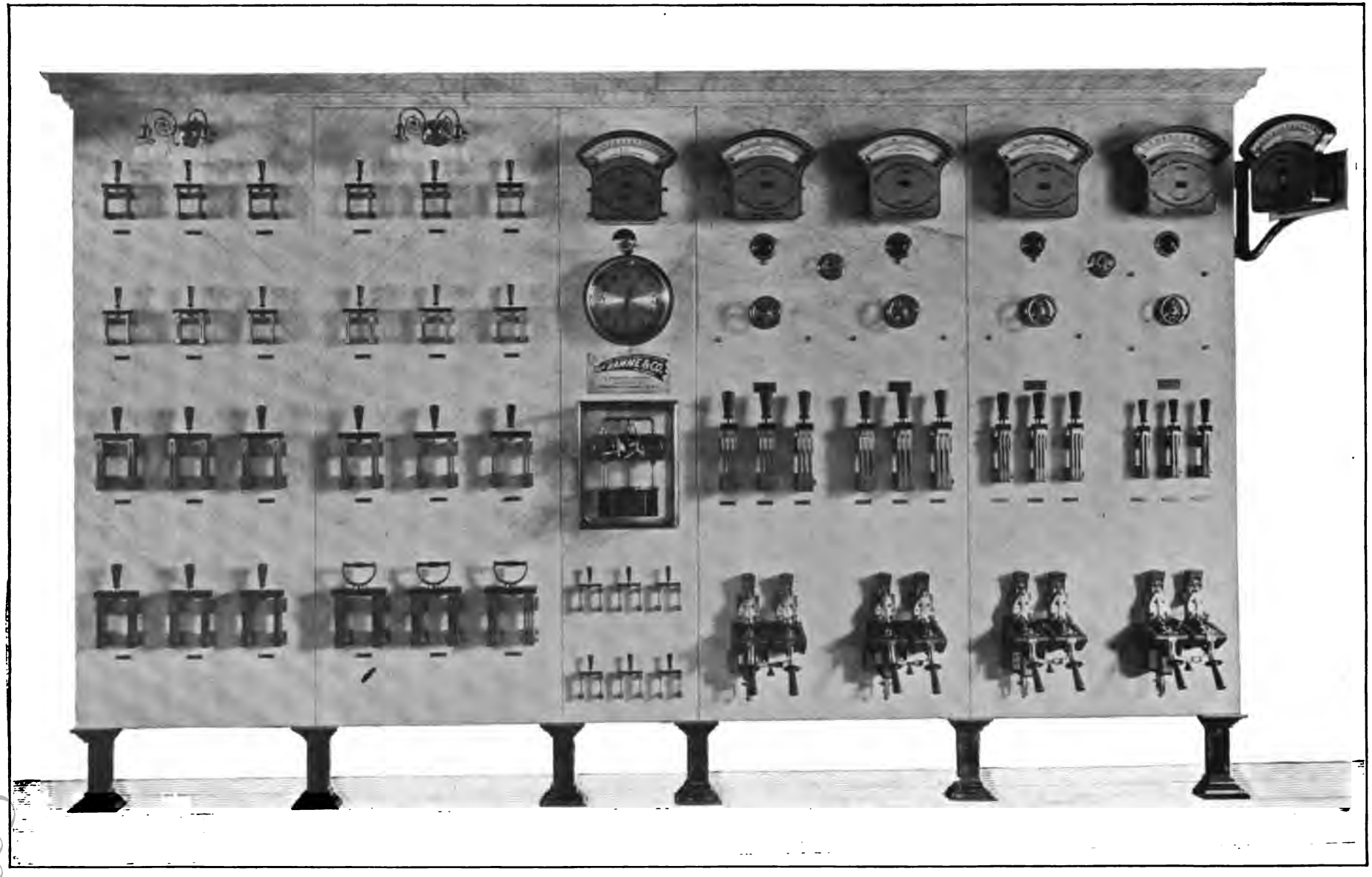
NEW YORK AND OHIO CO.
Packard Lamps and Transformers

A-B ARC LAMPS

THE B-R ELECTRIC COMPANY

Seventh and Wall Streets

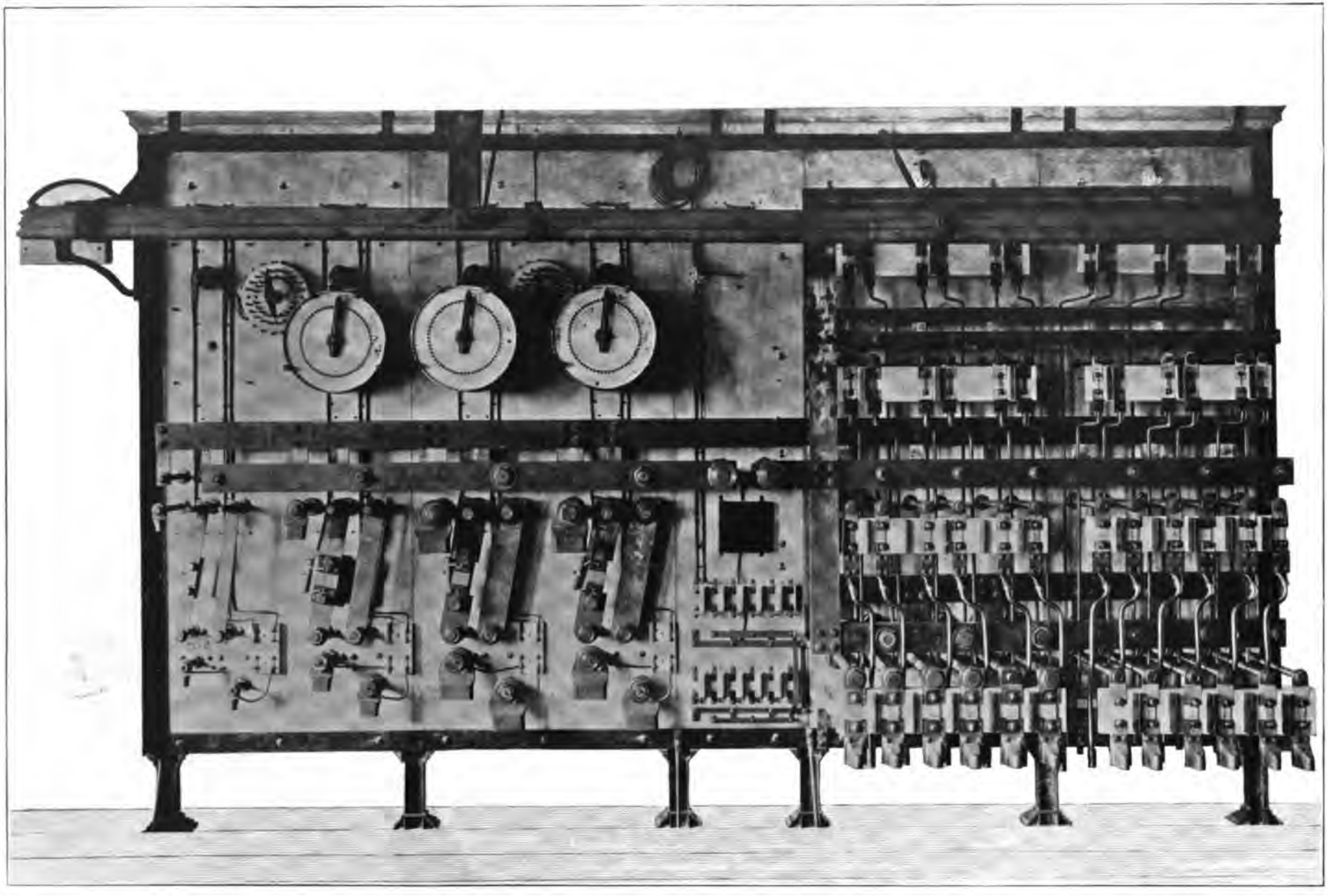
KANSAS CITY, U. S. A.



SWITCHBOARD ERECTED BY THOMPSON-STARRETT COMPANY

For Hahne & Co., Newark, N. J.

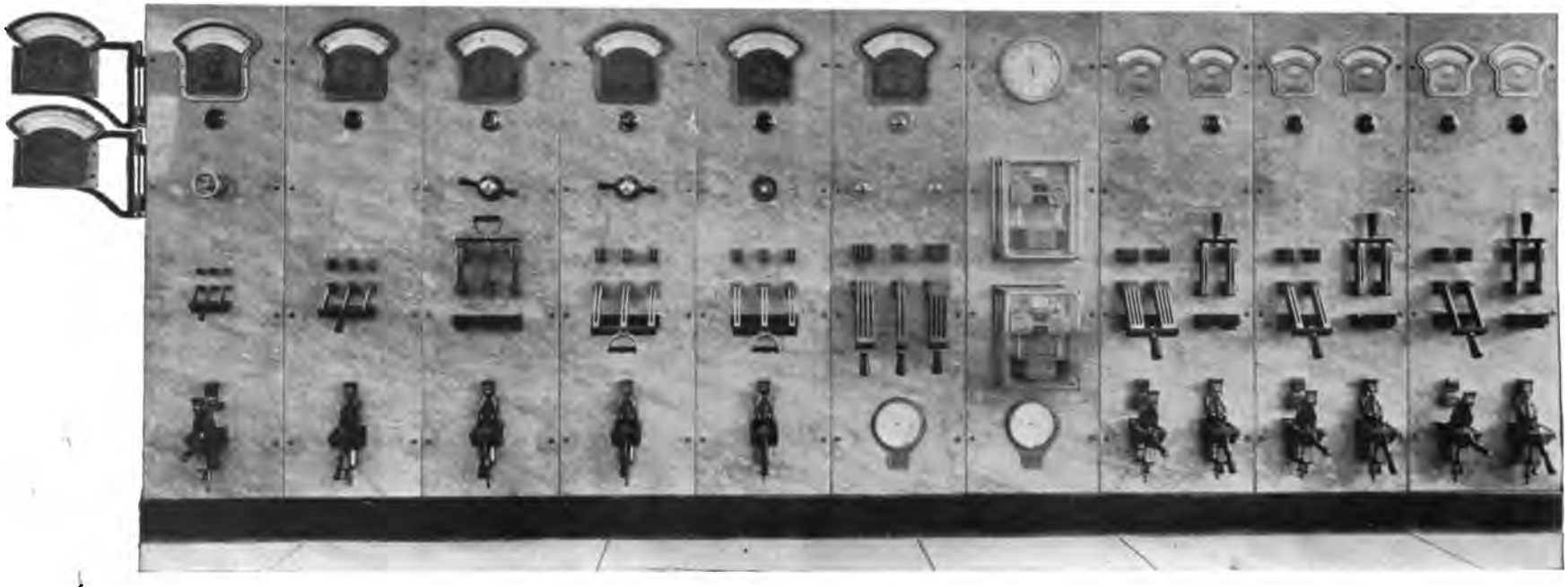
H. D. Babbitt, Engineer



REAR VIEW OF HAHNE & CO.'S SWITCHBOARD

Erected by Thompson-Starrett Company

H. D. Babbitt, Engineer



Switchboard Installed in

JOHN B. STETSON & CO.'S POWER HOUSE

Philadelphia

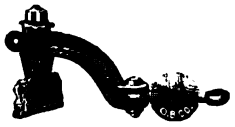
Built by The Walker Electric Company, Reg., Philadelphia

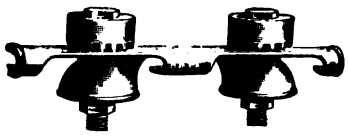
"The Largest Manufacturers of OVERHEAD LINE MATERIAL in the World"

The Ohio Brass Company

MANSFIELD, OHIO, U.S.A.

DESIGNERS MANUFACTURERS DEALERS





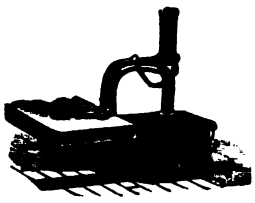
ELECTRICAL SUPPLIES

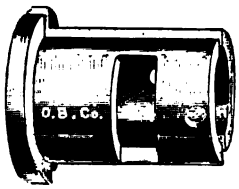
FOR

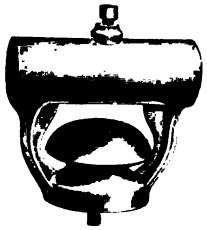
Electric Railway, Lighting and Power and Mining Plants

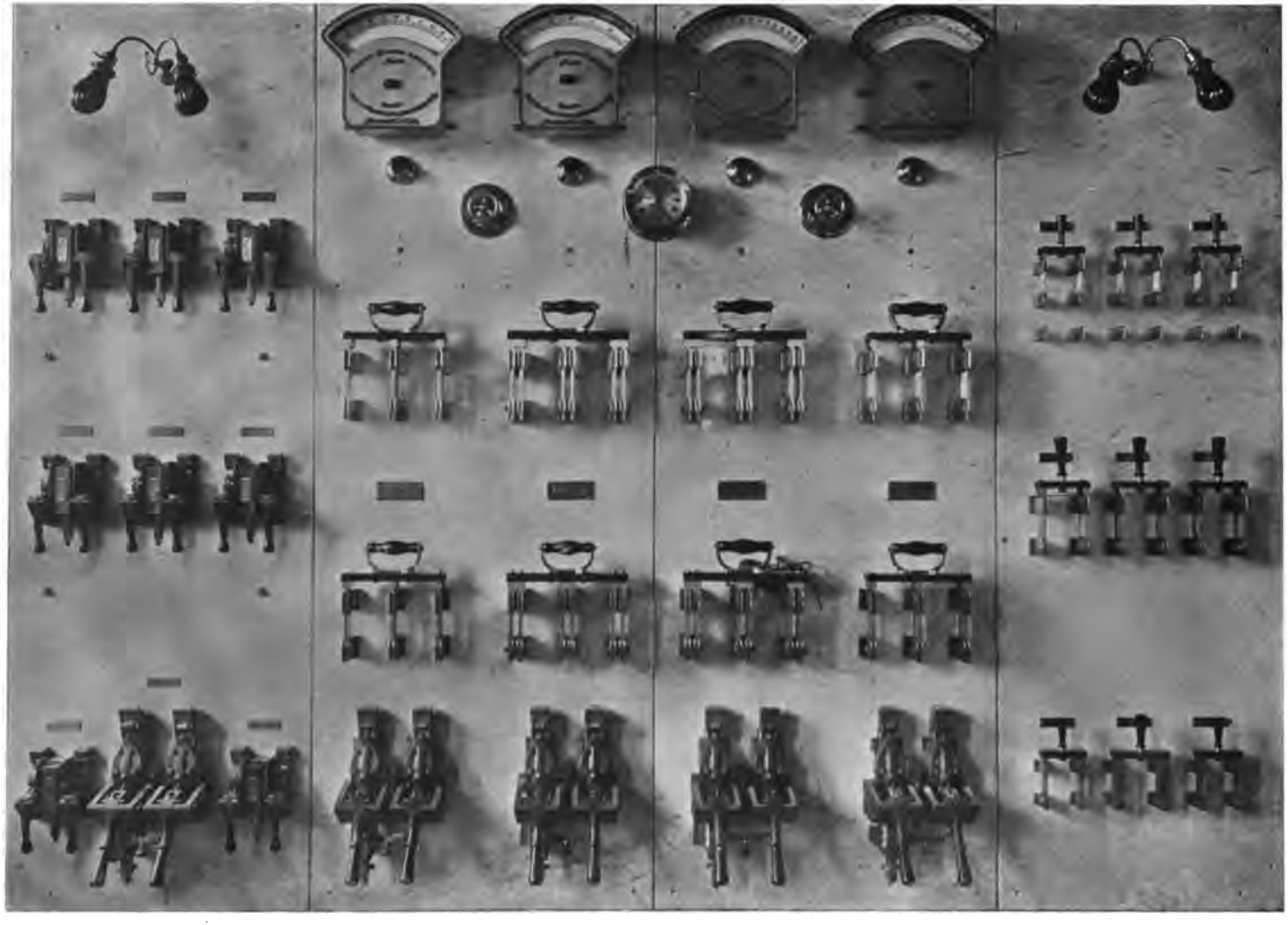
POLE BRACKETS
TROLLEY WIRE HANGERS
TROLLEY EARS AND CLAMPS
STRAIN INSULATORS

MOTOR BEARINGS
HIGH TENSION INSULATORS
"ALL WIRE" RAIL BONDS
CONSTRUCTION TOOLS, ETC.









KEYSTONE BANK BUILDING, Pittsburg, Pa.

Built by Krantz Manufacturing Company Installed by Thompson-Starrett Company

H. D. Babbitt, Engineer

Victor Pendant Burner

Telephone

Ajax Dry Battery

Our Prices are Right

WE carry a complete stock of Electrical Supplies of every description, and handle nothing but the best in their respective lines.

WE ARE AGENTS FOR

Crocker-Wheeler Motors and Dynamos
Peerless Fans and Transformers
Victor Incandescent Lamps
Manhattan Arc Lamps
Flexduct (the new Flexible Tubing)
Shield Brand W. P. and Office Wires
Standard Underground Cable Co.'s Wires and Cables
Viaduct Telephone Apparatus
Deveau Switchless Telephones

WE MANUFACTURE

Victor Pendant Burner
Victor Alcohol Torch
Crescent Shade
Ajax Dry Battery
Candelabra, Miniature and 9171 Receptacles, Panel Boards and Switchboards
Knife Switches and Electric Railway Supplies

ESTABLISHED 1883

Victor Torch

Receptacles

Crescent Shade

We Make Prompt Shipments

Vallee Bros. Electrical Co.

625 Arch Street, Philadelphia

WHOLESALE DEALERS IN EVERYTHING ELECTRICAL

Copper for Electrical Purposes

WE MAKE A SPECIALTY OF

Hard-Drawn Copper Commutator Bars

Perfectly Smooth, Free from Imperfections, True to Dimensions

Made in any size required

HARD-DRAWN COPPER BUS BARS

Square Edges, Perfect Surfaces, All Sizes

COPPER ROD, Round, Square, Hexagon and Octagon Shapes

COPPER AND BRONZE MOULDINGS AND CHANNELS

SPRING BRUSH COPPER

ALSO A FULL LINE OF

BRASS, COPPER, BRONZE AND GERMAN SILVER

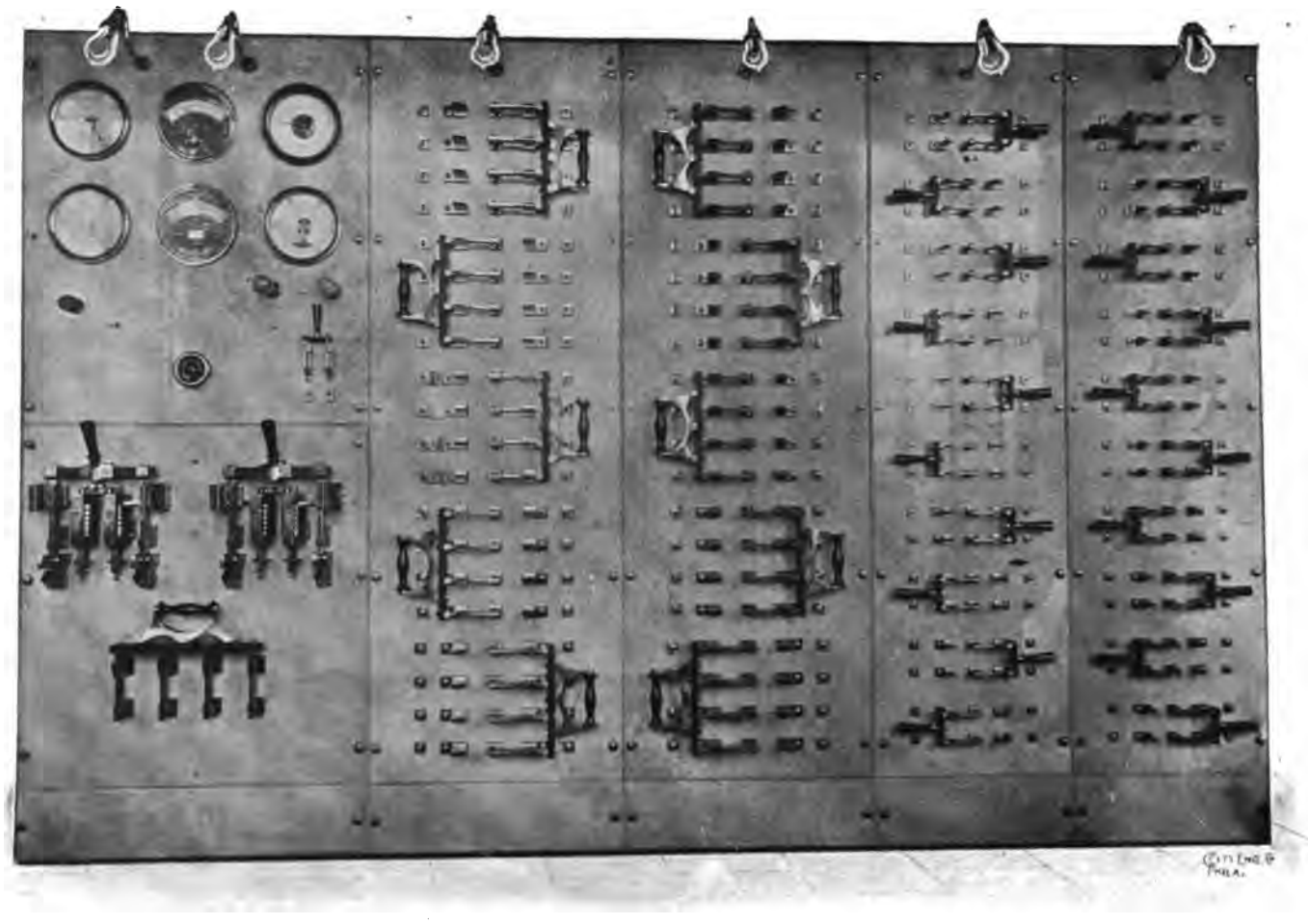
in Sheets, Plates, Rods, Wire, Rivets, Nails, Pins, Etc.

SEAMLESS BRASS AND COPPER TUBING

U. T. HUNGERFORD BRASS AND COPPER COMPANY

497 TO 503 PEARL STREET 35 TO 43 PARK STREET

NEW YORK



SWITCHBOARD ERECTED FOR UNION ABATTOIR CO., BALTIMORE

DR. W. A. DRYSDALE, Engineer — Built by Wm. T. Pringle

WM. T. PRINGLE

112-114 N. TWELFTH ST.

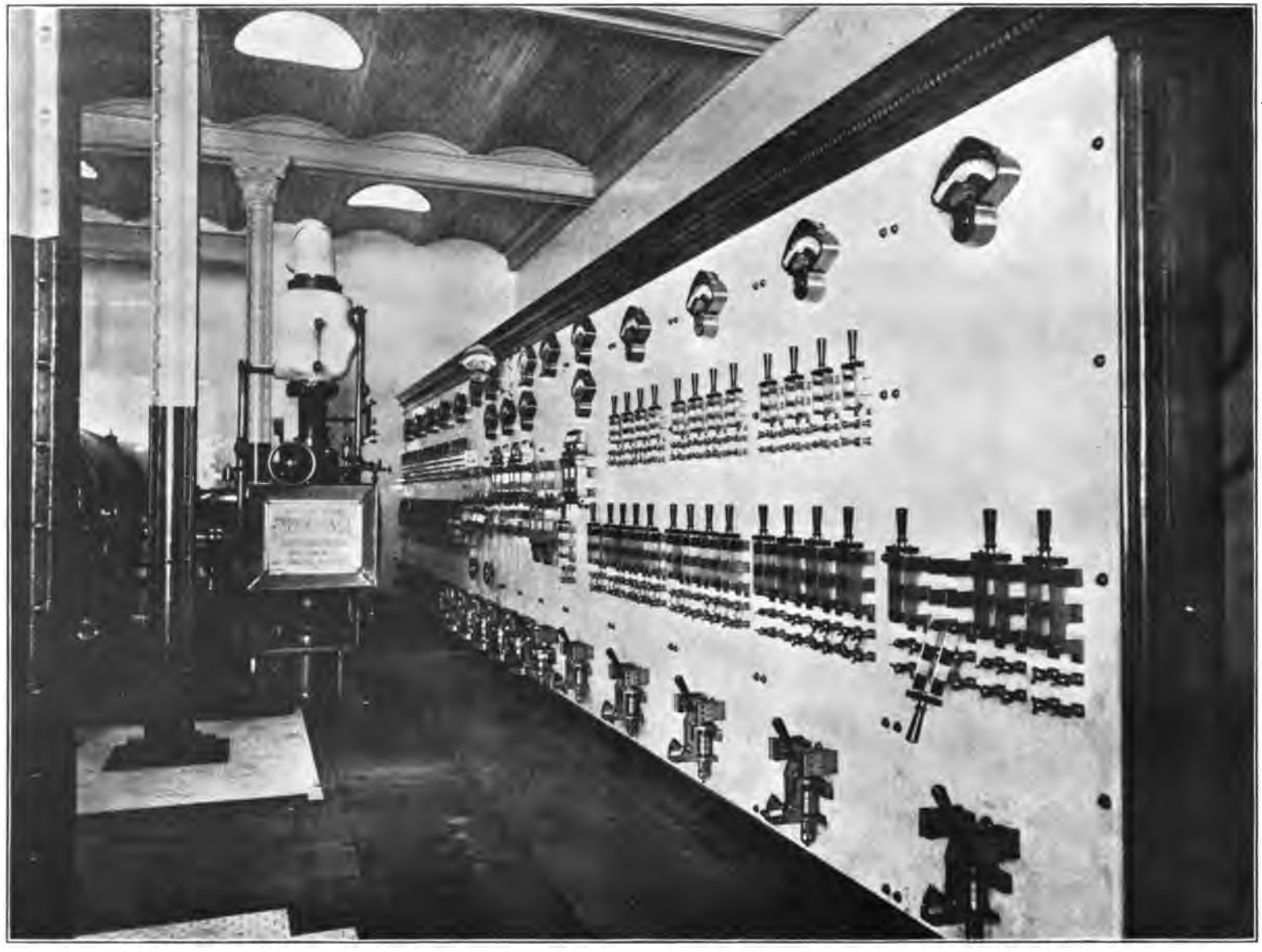
PHILADELPHIA, PA.

No second-grade material leaves our factory. Our sole aim is to give you the best obtainable at as low a cost as possible.

SWITCHBOARDS
PANEL BOARDS
SWITCHES

and in connection with the above a line of high-grade specialties, including

FLUSH RECEPTACLES
WATERPROOF RECEPTACLES (3 STYLES)
FLUSH KNIFE SWITCHES
RIES REGULATING SOCKETS



SWITCHBOARD INSTALLED IN THE NEW CITY HALL, Philadelphia

Equipped with Keystone Illuminated Dial Instruments and I-T-E Circuit Breakers

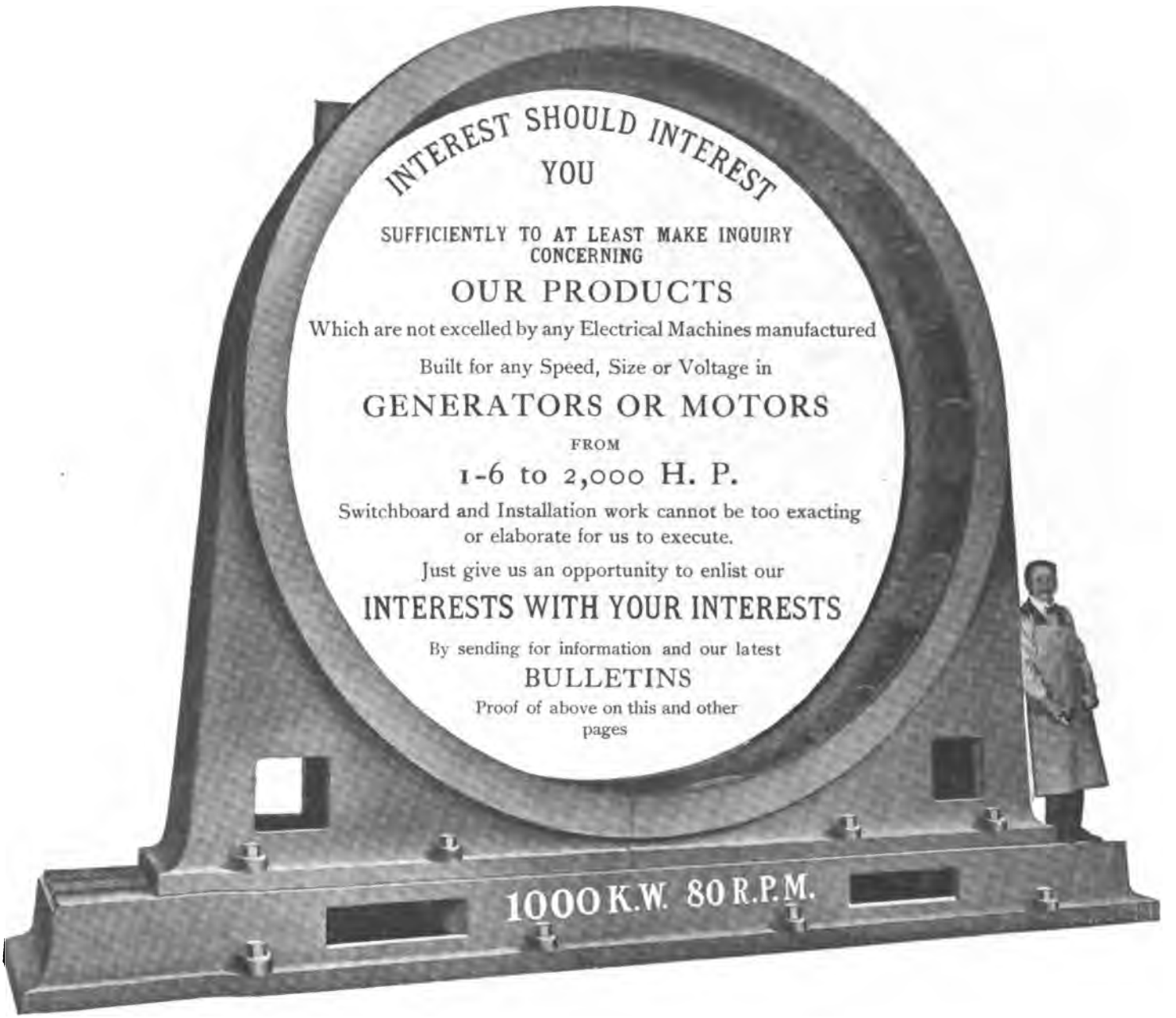
It makes little difference whether you go into a white marble palace or into a dirty machine shop—if the palace and machine shop are up-to-date, you will find I-T-E CIRCUIT BREAKERS. There is a reason for their being there.

If you can't afford to buy I-T-E CIRCUIT BREAKERS, don't buy any; save your money and use a fuse. They are better than nothing, and sooner or later you will get a circuit breaker—and when you get a circuit breaker, get a good one.

KEYSTONE ELECTRIC COMPANY

HIGH GRADE ELECTRICAL MACHINERY

MAIN OFFICE AND WORKS, ERIE, PENNA.



The Process Copper and Brass Co.

MANUFACTURERS OF

Pure Copper Castings, Solid and Free from Blow-holes

ALSO

Composition, Steam Metal, Yellow Brass, Red Brass, Brazing Metal Castings, Government Mixture, Hydraulic Metal, Phosphor-Bronze, Manganese Bronze, German Silver and Aluminum Castings

JERSEY CITY, NEW JERSEY

ELECTRIC

The Royal Electric Co., Montreal, Canada, on June 28, 1900, write:

DEAR SIRS:
Replying to your favor of the 25th inst., regarding compensating segments. The segments which we received from you proved to be entirely satisfactory.

The Royal Electric Co. were guaranteed 90 per cent. conductivity—**they got it.**

As to the general superiority and high conductivity of copper castings produced by us, we submit the following:

GENTLEMEN: PITTSFIELD, MASS., February 9, 1901.
Replying to your favor of the 8th inst., relative to castings which we have received from you, would say that your copper castings have been very satisfactory indeed as to uniform solidity and smooth surface—in fact they have been the most satisfactory copper castings we have been able to obtain up to this time.

Yours truly,
STANLEY ELECTRIC MFG. CO.
JOHN H. KELMAN, Gen'l Supt.

PITTSFIELD, MASS., October 3, 1901.

GENTLEMEN:
Replying to your recent favor relative to the **high conductivity** castings which you furnished us, **you guaranteeing a conductivity of 90 per cent.**, would say that we have found the same satisfactory. Yours truly,
STANLEY ELECTRIC MFG. CO.
F. R. WHITTLESEY, Purchasing Agent.

The Cutter Electrical and Manufacturing Company, of Philadelphia, Pa., write:

"We are sending you by express to-day quite a large pattern, from which we wish to have five copper castings made. **You at one time made for us some copper which we found by test to have a carrying capacity of 92 per cent.** This is the material we are desirous of obtaining for this particular job, and we feel confident that you can supply it. We are in urgent need of these castings, and would esteem it a special favor if you would give same your immediate attention."

Again the Cutter Electrical and Manufacturing Company, of Philadelphia, Pa., write:

"Please advise us if you are manufacturers of red brass castings. If so, what could you do our work for? The castings run about the same as the copper—possibly a little heavier. **It will be necessary for them to be perfectly solid, without blow-holes, just as you are making the copper.**"

The Crouse-Hinds Electric Company, of Syracuse, N. Y., write:

"The quality is certainly very fine."

The Wm. Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa., state:

"The bar has been examined and tested—we shall endeavor to recall your abilities."

The Crocker-Wheeler Company, of Ampere, N. J., write:

"The sample of cast copper which you sent us shows very good quality upon test, and appears perfectly satisfactory."

We take pleasure in referring to the WESTON ELECTRICAL INSTRUMENT COMPANY, of Newark, N. J. This well-known company will undoubtedly be pleased to state that our copper castings are superior in every respect.

NON-CORROSIVE METAL

Copper resists to a very great extent the chemical action of the elements.

In this connection read this letter of inquiry from Garner & Co., of New York City, the largest manufacturers of the kind in the country:

NEW YORK CITY, June 5, 1901.

The Process Copper and Brass Co., 42 and 44 Hudson Street, Jersey City, N. J.

GENTLEMEN:
Please name us your lowest price per lb. f.o.b. Hudson River R. R., for two (2) Cast Copper Sleeves or Rings, that will finish 19 in. long, 18⅛ in. outside diameter, by 16⅞ in. inside diameter, to be pure copper, solid and free from blow-holes, as they are to be used in acid; also say when you could furnish them, and oblige,

Yours truly,
GARNER & CO.

In reply to their valued favor we quoted them our price on

PURE COPPER CASTINGS—SOLID—AND FREE FROM BLOW-HOLES

On June 11, 1901, Messrs. Garner & Co. gave us the following order:

GENTLEMEN:
Replying to your favor of the 6th inst., you will please make for us two (2) Cast Copper Sleeves that will finish 19 in. long, 18⅛ outside diameter, by 16⅞ inside diameter, to be of pure copper, solid and free from blow-holes.

The Sleeves were made—**they were perfect castings.**

Office of GARNER & Co.
Nos. 2, 4, 6, 8, 10, 12, 14 and 16 Worth St.,
Corner Hudson Street,
NEW YORK, September 16, 1901.

Process Copper and Brass Co., 42 and 44 Hudson Street, Jersey City, N. J.

GENTLEMEN:
Replying to your favor of the 11th inst. The Copper Sleeves finished up all right, and so far have given satisfaction.

Yours truly,
GARNER & CO.,
Per Hibbard.

The Sleeves Are Showing Great Durability

Crocker-Wheeler Company

Manufacturers and Electrical Engineers

Builders of Direct Current Dynamos and Motors

IN MANY TYPES AND SIZES

Our machines have won a reputation as being Reliable, Efficient and Economical

We are enabled to maintain this reputation by constant care in design and construction

Manufacturers, machine-shop men and users in general of electric power will find it to their interest to advise us of their wants before purchasing

Main Office and Works, AMPÈRE, N. J.

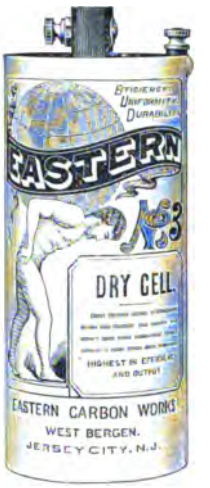
BRANCH OFFICES

BOSTON	PHILADELPHIA	CHICAGO
NEW YORK	PITTSBURG	DENVER
WASHINGTON	ST. LOUIS	SAN FRANCISCO

EASTERN CARBON WORKS

Jersey City, N. J.

The Largest Manufacturers of Carbon Batteries
in the world



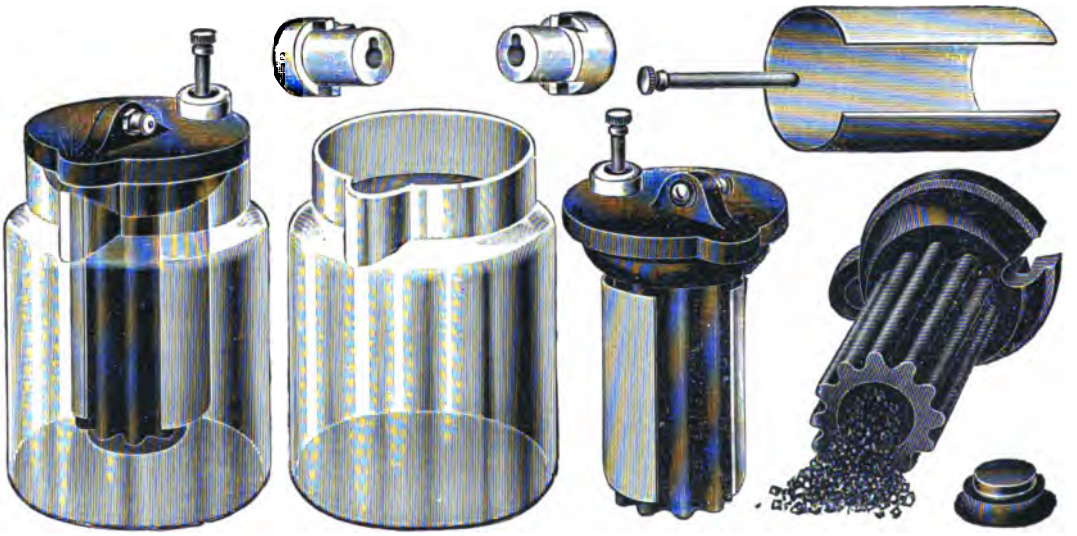
OUR LEADERS

Eastern Carbon Cylinder Batteries } For Bell Work, Telephones
Eastern No. 3 Dry Batteries, standard size, 2½ x 6 } Annunciators, etc.

Eastern No. 1 Carbon Porous Cup Cell } Standard Types for Gas Engines
Eastern No. 4 Dry Battery, size, 3½ x 8 } and Electric Gas Lighting

Also every other known type of Carbon Battery

OUR BATTERIES ARE STRICTLY HIGH-GRADE



EASTERN No. 1 CARBON POROUS CUP CELL AND PARTS

GENERATOR AND MOTOR BRUSHES

We make more types of the above than any other manufacturer in the world, and a trial order will convince you of their all-around merit

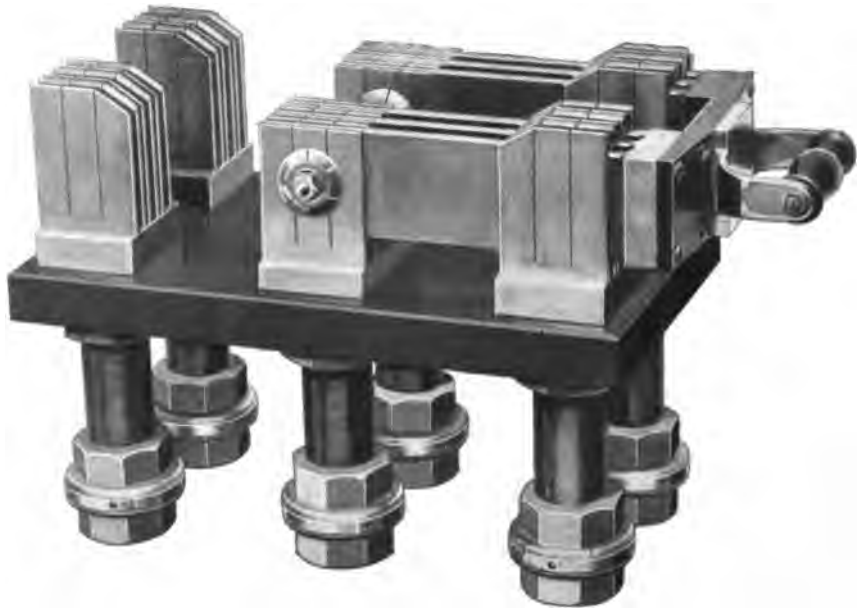
CARBONIZED WORK OF EVERY DESCRIPTION

We make a specialty of EXPERIMENTAL work and can aid you with our experience of over fifteen years

EASTERN Carbons are used exclusively for "I-T-E" Circuit Breakers

SWITCHES *and* SWITCHBOARDS

of approved construction and best material
and workmanship

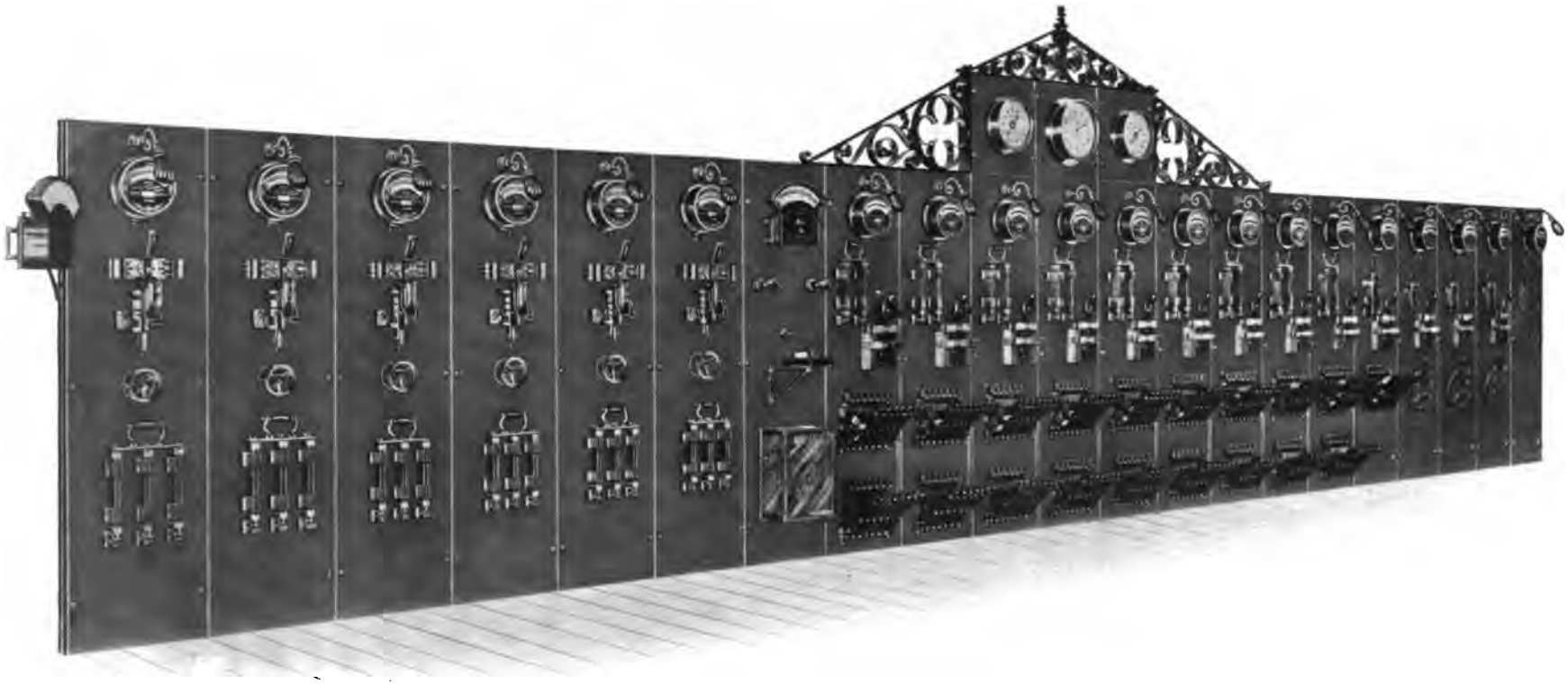


Knife Switches, Quick-Break Switches, Volt-Meter Switches
Service Switches, Section Switches, End-Cell Switches
Special Switches to order.

Albert & J. M. Anderson Mfg. Co.

New York Office, 135 Broadway
Philadelphia, Girard Building

BOSTON, MASS.



Switchboard of

THE WHITEHALL PORTLAND CEMENT COMPANY

Cementon, Penna.

Built and Installed by The Keystone Electric Company, Erie, Penna.

SUBJECT:

STRIP AND BAR COPPER

ELECTRICAL MANUFACTURERS.

GENTLEMEN:

Just a word in reference to Strip and Bar Copper for electrical use.

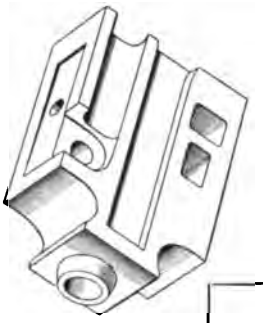
We carry a large stock of the standard sizes; prompt shipments are thus insured.

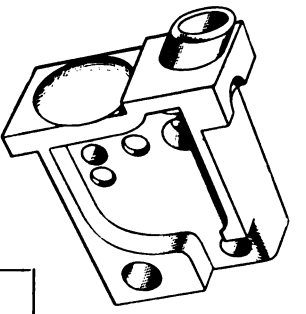
All orders for stock sizes shipped the day order is received.

We shall be glad to serve you, and we are

Yours very truly,

A. P. SWOYER COMPANY,
17 North Seventh Street,
Philadelphia, Pa.





The Star Porcelain Co.

MANUFACTURERS OF

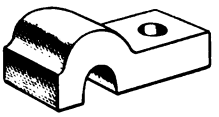
Electrical Porcelain

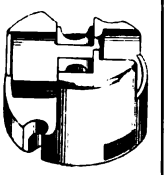
HOME OFFICE AND WORKS:

TRENTON, N. J.

PHILADELPHIA OFFICE:

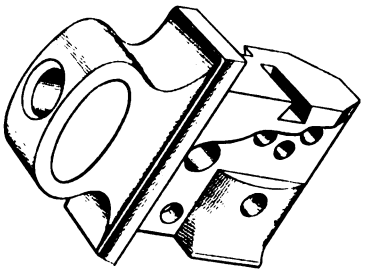
1020 STEPHEN GIRARD BUILDING

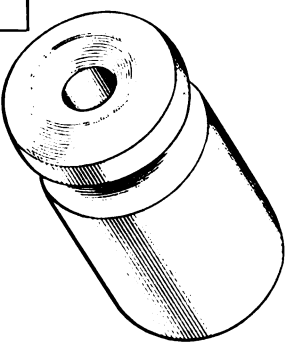




We are to-day making the most difficult and complicated pieces of Porcelain connected with electrical work, and give special attention to such designs.

We gladly furnish estimates from models or drawings and guarantee satisfaction as to quality and workmanship.





I-T-E Catalogue

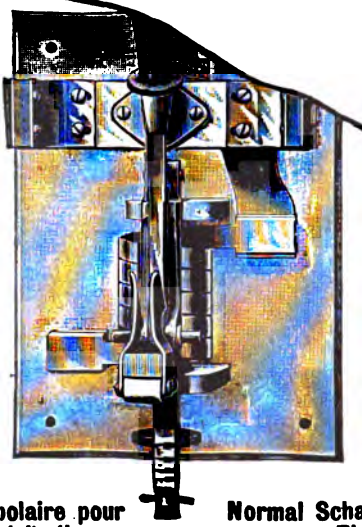
in English, French German *and* Spanish

85 Pages

tomatic Circuit Breaker **Disjonc**

Courant Continu
Gleichstrom
Corriente Directa

Code Word / Code / Kabel Wort / Clave	Normal Capacity / Courant Moyen / Normale Stromstärke / Corriente Normal	Calibration / Calibre / Kalibrirung / Calibracion	Price / Prix / Preis / Precio
Bacon	80 Amps.	60— 120 Am.	$65.25
Bail	100 "	75— 150 "	65.25
Bead	150 "	110— 225 "	65.25
Behest	200 "	150 — 300 "	67.50
Bias	300 "	225 — 450 "	81.75
Blonde	400 "	300— 600 "	91.50
Boast	500 "	375— 750 "	96.00
Bolster	600 "	450— 900 "	100.50
Brunette	700 "	525—1000 "	107.25
Bonanza	800 "	600—1200 "	135.00
Bower	1000 "	800—1500 "	153.50
Broom	1250 "	900—1800 "	168.75
Brynx	1500 "	1200—2250 "	195.00



Alternating Current
Courant Alternatif
Wechselstrom
Corriente Alterna

Balt...		
Balster		
Baltette		
Baltanza	800	"
Baltower	1000	"
Baltoom	1250	"
Baltynx	1500	"

Standard Switchboard Type—Single Pole

For Direct or Alternating Current

For use on Circuits of 600 Volts or under

BACK OR FRONT CONNECTION

This instrument is the accepted standard, and has won for itself the highest place in the opinion of all users of high-grade electrical apparatus; for the service which it is intended it has no superior. ... with careful attention to every detail, the standard for switchboard ... protection of light, heat and ... or for use in connection ...

... see page 10. For ... 150 amperes ca... of doubly in... enameled. ... made of ...

Type normal unipolaire pour tableau de distribution

Pour courants continus ou alternatifs

Devant s'employér sur des circuits de 600 volts ou au-dessous

CONNEXIONS DEVANT OU D'ARRIÈRE LE TABLEAU

Cet appareil est l'étalon reconnu comme tel, et s'est acquis la plus haute place dans l'opinion de tous ceux qui emploient les meilleurs appareils électriques, car dans le service qu'il est appelé à rendre il n'a pas d'égal. Dessiné avec la plus grande attention dans tous ses détails il est l'étalon pour le travail des tableaux de transmission pour la protection des circuits de lumière, de chaleur ou les circuits moteurs, ou pour etre employé pour le service des grands moteurs.

Fini—Type principal voir page 11. Pour disjoncteurs jusqu'à 150 ampères, les bobines sont faites de fils à double ... et ... enablement émaillées. ... les ...

Normal Schalttafel Type—Einpolig

Für Gleichstrom oder Wechselstrom

Für Stromkreise von 600 Volt oder weniger

ANSCHLUSS VON DER RÜCKSEITE ODER VON VORN

Dieses Instrument ist das anerkannte Normal Instrument und hat für sich den höchsten Ehrenplatz in dem Urtheil aller gewonnen, die elektrische Instrumente bester Qualität benutzen; für den Dienst, für den es bestimmt ist, hat es nicht seines gleichen Construirt mit sorgfältiger Berücksichtigung aller Einzelheiten, ist es das Normal-Instrument für Schalttafeln, für den Schutz von Stromkreisen für Licht, Wärme, und Kraftzwecke, oder für den Gebrauch bei grossen Motoren.

Ausführung—Normal, siehe Seite 12. Für Ausschalter bis zu 150 Ampere Capacität sind die Spulen aus doppelt isolirtem Magnetdraht hergestellt und passend emaillirt. Für grössere Capacitäten sind die Spulen aus blankem, rechteckigen Kupfer hergestellt.

Montage—Normal, siehe Seite 13. Für Instrumente, die auf Grundtafeln von weissem Marmor montirt sind, ist der Preis um je $3.00, Catalog-Preis, höher.

Grösse der Grundplatte — 700 ... ampere oder weniger = 25 cm. × 36 cm. × 38 mm.; 800 bis 1500 Ampere = 30 cm. × 38 cm. × 44 mm.

Speciell—Wenn speciell so gewünscht, werden die Instrumente für Anschluss von vorn geliefert, zu demselben Preise, wie für Anschluss von der Rückseite.

Notiz.—Für weitere Einzelheiten ...sichtlich dieser Type sei auf Seite 7 ...wiesen.

...-700 Amps.
... Netto Gewicht . . . . 23 kg.
... Tara " . . . . 11 "
...rutto " . . . . 34 "
... Dimensionen der Instrumente ...rsendung, 48 x 33 x 43 cm.

...ps.
...ht . . . . 36 kg.
... . . . 14 "
... . . . 50 "
... Instrumente
... x 46 cm.

... min-
... der
...

Tipo "Tabla de Distribución Modelo"—Polo Sencillo

Para Corriente Directa ó Alterna

Para Circuitos de 600 Volts ó menos

CONEXIÓN POSTERIOR Ó FRONTAL

Este instrumento es el reconocido como norma; y se ha ganado el más alto puesto en la opinión de todos los que usan aparatos eléctricos superiores. Para el trabájo á que se le destina no tiene rival. Dibujado con el mayor esmero en todos sus detalles, es el modelo de obra en tablas de distribución, para la protección de los circuitos de luz, calor y fuerza; ó para su uso en conexión con los grandes dinamos.

El Acabado—Modelo véase la página 10. Para corta-circuitos hasta de 150 amperes los carretes se hacen de alambre imantado de doble aislamiento, convenientemente esmaltados. Para los tamaños mayores los carretes se hacen de puro cobre rectangular.

Montura—Modelo, véase la página 10. Se montan instrumentos sobre bases de mármol blanco por $3 cada uno, extra, según lista.

Tamaño de Base—700 amperes ó menos = 25 cm. x 36 cm. x 38 mm. 800 á 1500 amperes = 30 cm. x 38 cm. x 44 mm.

Especial—Se entregarán instrumentos provistos de conexiones frontales al mismo precio que los de conexiónes posteriores, al solicitarse así especialmente.

NOTA.—Para otros informes respecto á este tipo, véase la página 6.

80-700 Amps.
Peso Neto . . . . 23 kg.
" de la Tara . . . 11 "
" Bruto . . . . 34 "
Dimensiones Cúbicas del Instrumento ya listo para il embargue, 48 x 33 x 43 cm.

800-1500 Amps.
Peso Neto . . . . 36 kg.
" de la Tara . . . 14 "
" Bruto . . . . 50 "
Dimensiones Cúbicas del Instrumento ya listo para il embargue, 61 x 36 x 46 cm.

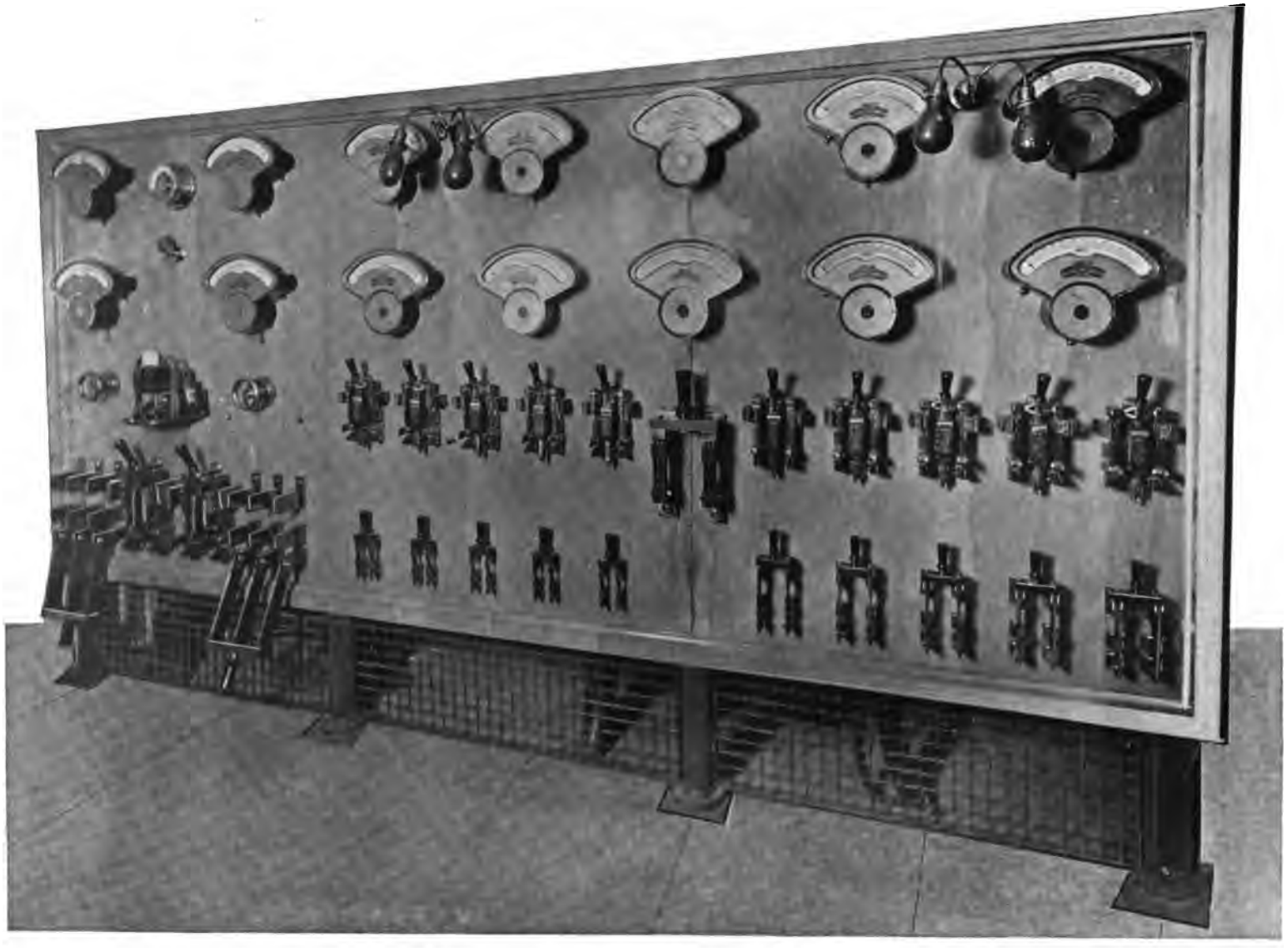
Para evitar la sustitución de aparatos inferiores al hacer pedidos debe uno copiar las letras I-T-E y añadir "fabricado por la Cutter Co."

We will be glad to send without charge our new Polyglot Catalogue, the most complete Circuit Breaker Catalogue published.

The Cutter Company

19th and Hamilton Sts.

Philadelphia, U. S. A.



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Installed by Northern Engineering Company

TELEPHONE CONNECTION
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CHICAGO, ILL.
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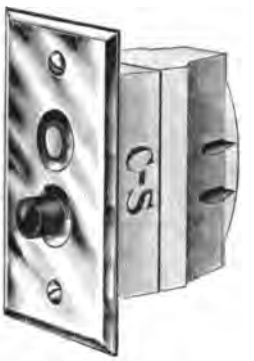
MERIAM ABBOTT CO.

NATIONAL ELECTRICAL SUPPLY COMPANY



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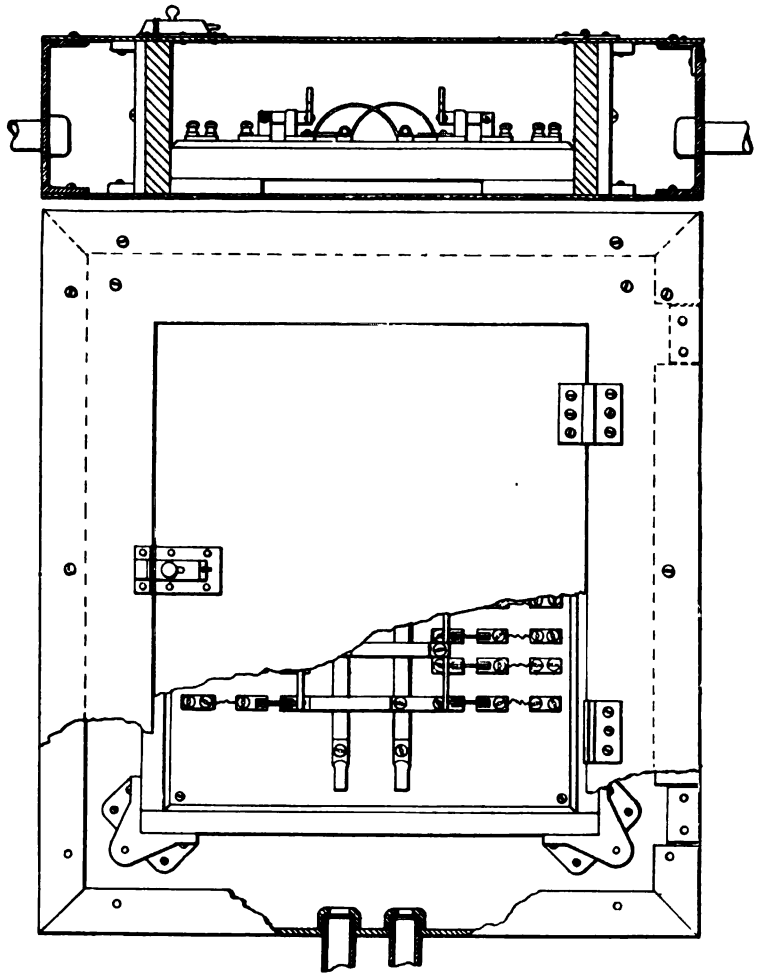
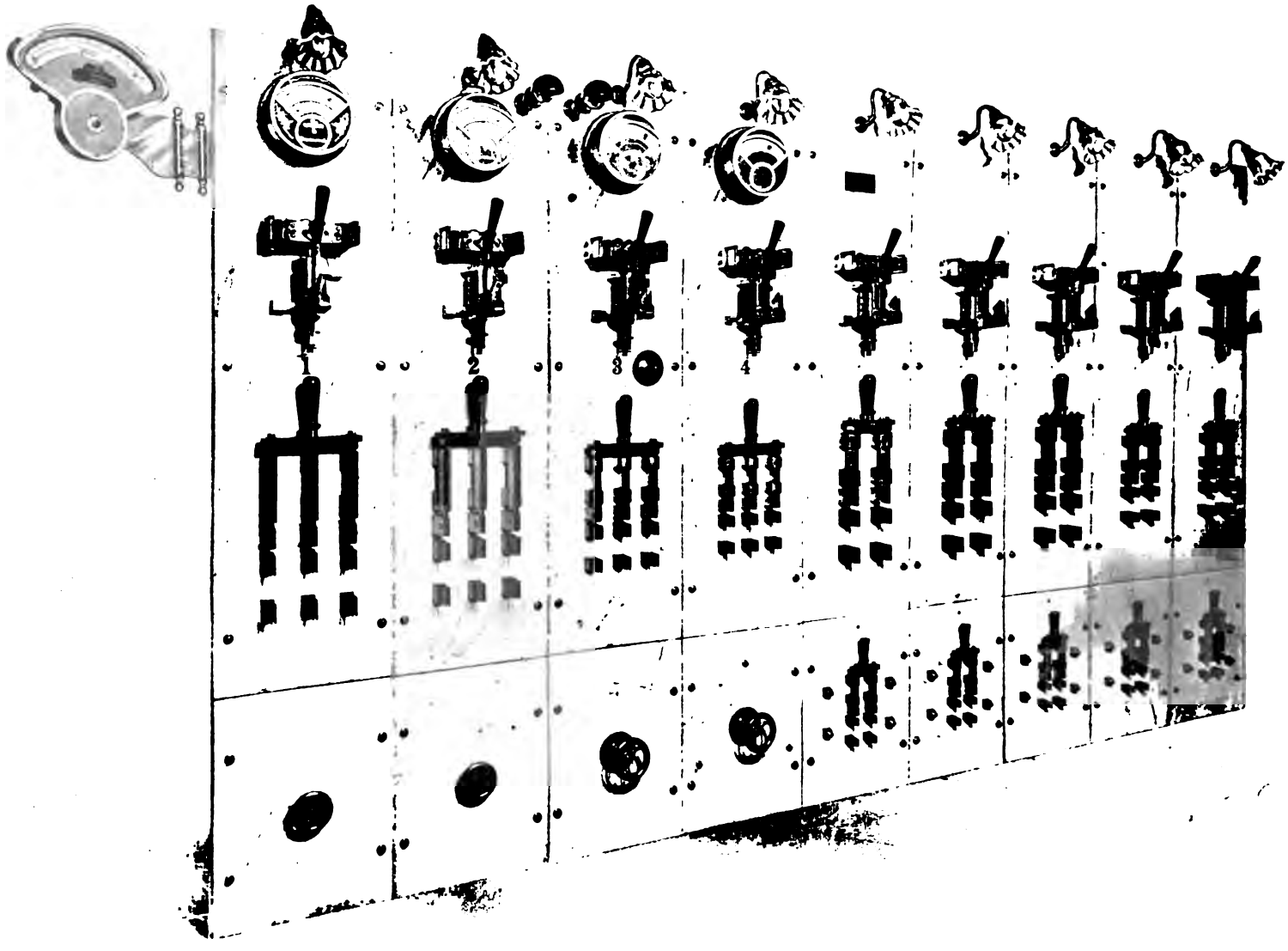
MANUFACTURERS OF THE MOST APPROVED TYPES OF PANEL AND SWITCHBOARDS



Panel Boards manufactured under United States Patents Numbers 614, 882, 640, 482, 623, 172, and other patents pending

Superior design and construction. Easy to install and accessible. An opportunity to bid on your work is solicited.

We have compiled a little pamphlet on panel boards showing the superiority of our work. Data of value to the engineer and electrician is also included. This circular may be had for a postal.



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MANUFACTURERS OF

High-Grade Switches, Switchboards, Etc.

FOR ALTERNATING OR DIRECT CURRENT

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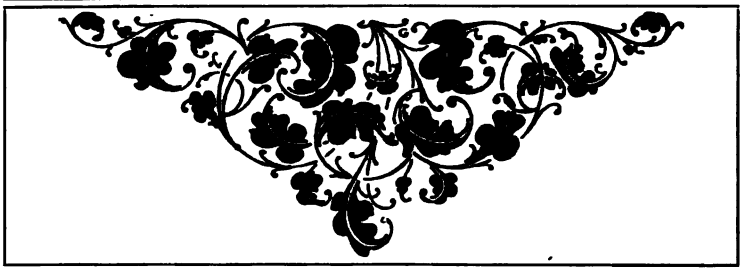

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We install complete electric lighting or power plants

We install electric wiring for light or power

We install interior telephone, signaling and burglar alarm systems.

We build switchboards and panel boards.

We build electric railways.

We equip newspaper printing presses with our patented system of electrical control.